Sacramento-San Joaquin Delta Historical Ecology Investigation

Robin Grossinger

Alison Whipple

Delta Stewardship Council

November 15, 2012

SFEI ASC

ECOSYSTEM RESTORATION PROGRAM

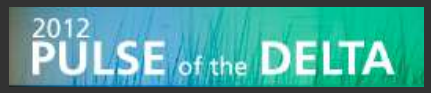
California Department of Fish & Game
National Oceanic & Atmospheric Administration
US Fish & Wildlife Service

San Francisco Estuary Institute
—
Aquatic Science Center

- SFEI formed in 1993
- Towards a **comprehensive, coordinated Regional Monitoring and Research Strategy** to assess the chemical, physical and biological health of the Estuary
- BOD represents agencies, NGOs, industry
- 50 staff
- Administers a **Joint Powers Authority** of the state: the Aquatic Science Center (ASC)
- → *Impartial environmental science synthesis for the region*

Programs

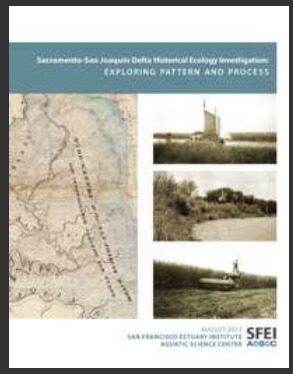
Clean Water



Nutrient Analysis

EDIT (Environmental Data, Information, and Technology)

Resilient Landscapes



Talk outline

- What is historical ecology and why is it useful?
- How do we do historical ecology?
- Findings of the *Delta Historical Ecology Investigation*
- How is this information being used?

Talk outline

- What is historical ecology and why is it useful?
- How do we do historical ecology?
- Findings of the *Delta Historical Ecology Investigation*
- How is this information being used?

"'Coequal goals' means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place." (CA Water Code §85054)

"'Coequal goals' means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place." (CA Water Code §85054)

“Ecosystem restoration cannot restore the historical Delta.”

Final Draft Delta Plan (page 143)

yet…

“…restoration seeks to return areas to a close approximation of their natural potential, including reestablishing natural habitat and ecosystem functions, as feasible…

Final Draft Delta Plan (page 145)

Similar in BDCP, ERP, PPIC

“… the first step in a river restoration program should be to develop a solid understanding of what the targeted rivers were actually like before the changes that restorationists seek to undo or mitigate.”

Montgomery 2008 (*Science 319*: 292)

The purpose of historical ecology:

not just to understand ***the way things were***

but to understand ***the way things work***.

(after Safford 2012)

→*Both opportunities **and** constraints*

→*Practical, efficient approaches*

- “Extensive **wide bands or large patches** of interconnected valley/foothill riparian forests…”
- “Produce **sinuous, high-density**, dendritic networks of tidal channels through tidal areas…”
- “Restore and sustain **a diversity of marsh vegetation** …”

-- Bay Delta Conservation Plan draft

*"Restore **large areas** of **interconnected habitats** within the Delta and its watershed by 2100"*

- Water Code section 85302

*"Restoration of the health of the Delta's ecological systems by addressing **ecological functions and processes at a broad landscape scale**"*

- Bay Delta Conservation Plan draft

*"Management plans and decisions need to be informed by a **landscape perspective** that recognized interrelationships among patterns of land and water use, patch size, location and connectivity, and species success."*

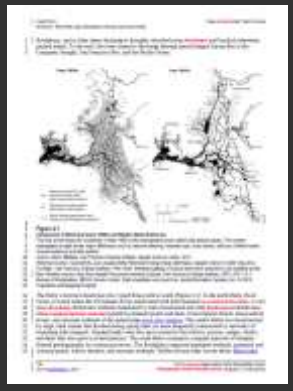
- Delta Plan draft

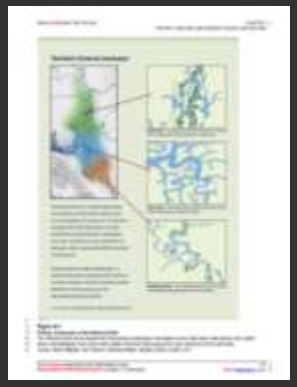
- How large is large?
- What should be connected to what?
- What is the whole that the parts add up to?
- And how does that look in different parts of the Delta?

→ a landscape vision

Delta historical ecology already being applied

- Advance thinking among scientists and managers towards specific goals and objective
- Incorporated into BDCP, ERP, and Delta Plan drafts
- McCormick-Williamson tract restoration planning
- Cache Slough complex restoration planning
- Delta Landscapes Project: translating historical ecology into landscape-scale restoration tools





Talk outline

- What is historical ecology and why is it useful?
- How do we do historical ecology?
- Findings of the *Delta Historical Ecology Investigation*
- How is this information being used?

Historical ecology process

Collection

Compilation

Synthesis

Interpretation and Analysis

Reporting

1800

Archaeology reports, tribal Representatives

Explorer journals

1850

Travelogues/memoirs

Diseños, court testimony

1900

Maps and surveys

Landscape photos and art

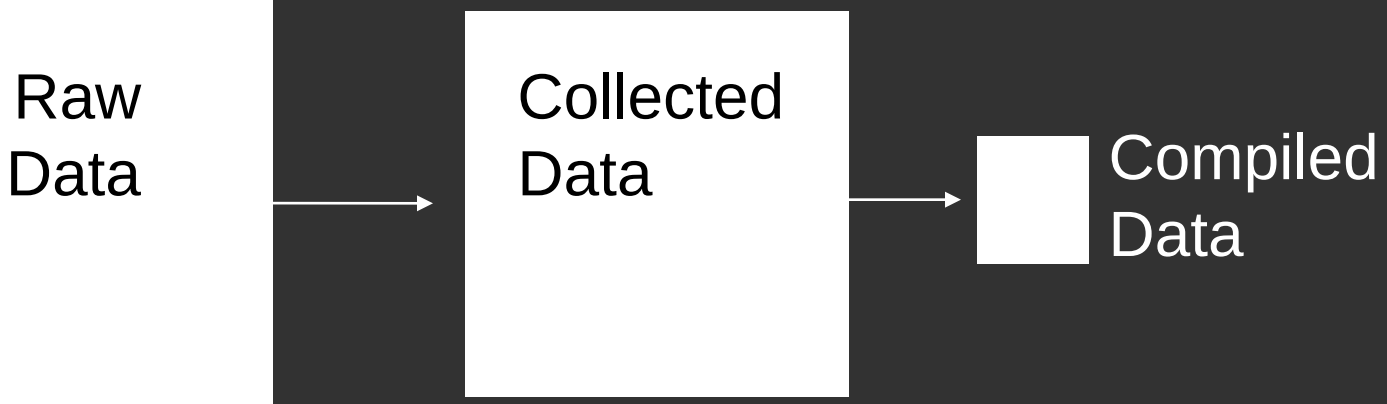
1950

Aerial photography

Interviews

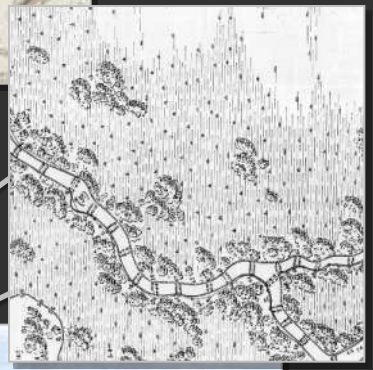
Scholarly & professional reports & records

2000


Raw
Data
Collected
Data
Compiled
Data

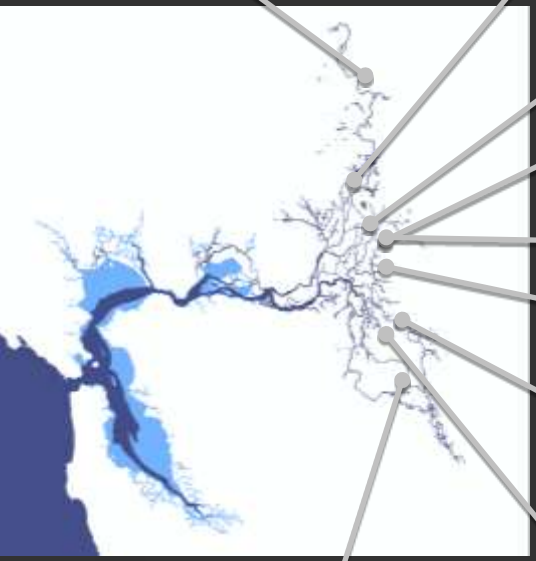
"The lake was situated far out in an impenetrable tule swamp of immense extent…it was a sort of "sanctuary" to which birds came…"

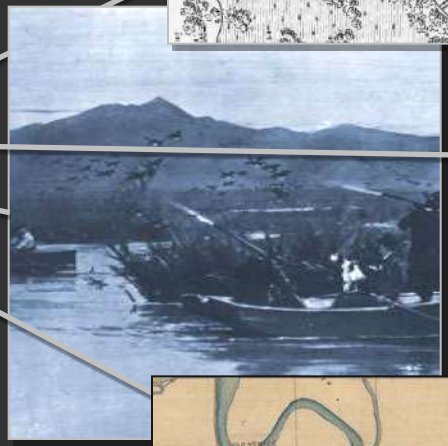
1800

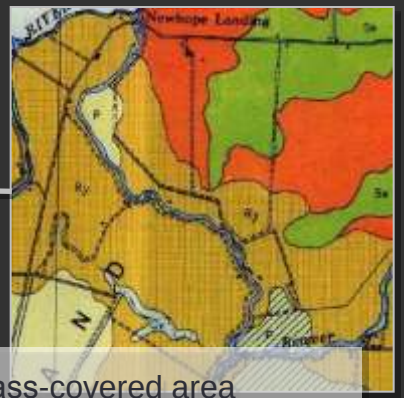


"lagoons…whose waters flowed back swiftly into the Sacramento with the ebbing tides"

1850

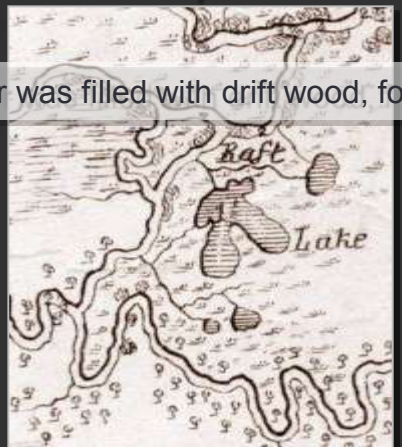






"In a grass-covered area between the forest and swamp"

1900

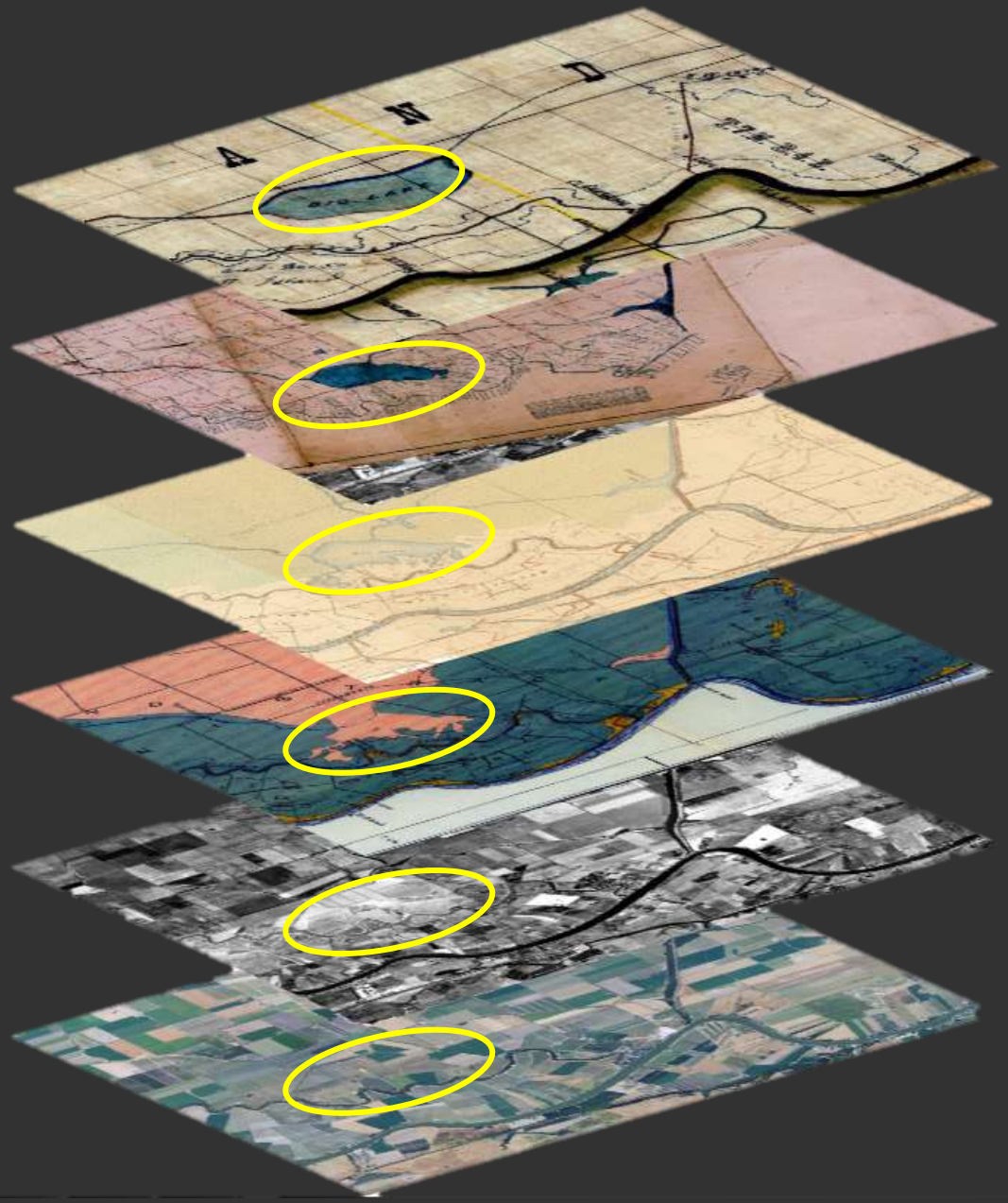


"the river was filled with drift wood, forming a raft"

"nothing but tule, without a tree under which the navigator may find shade"

1950

2000



ca. 1880

1914

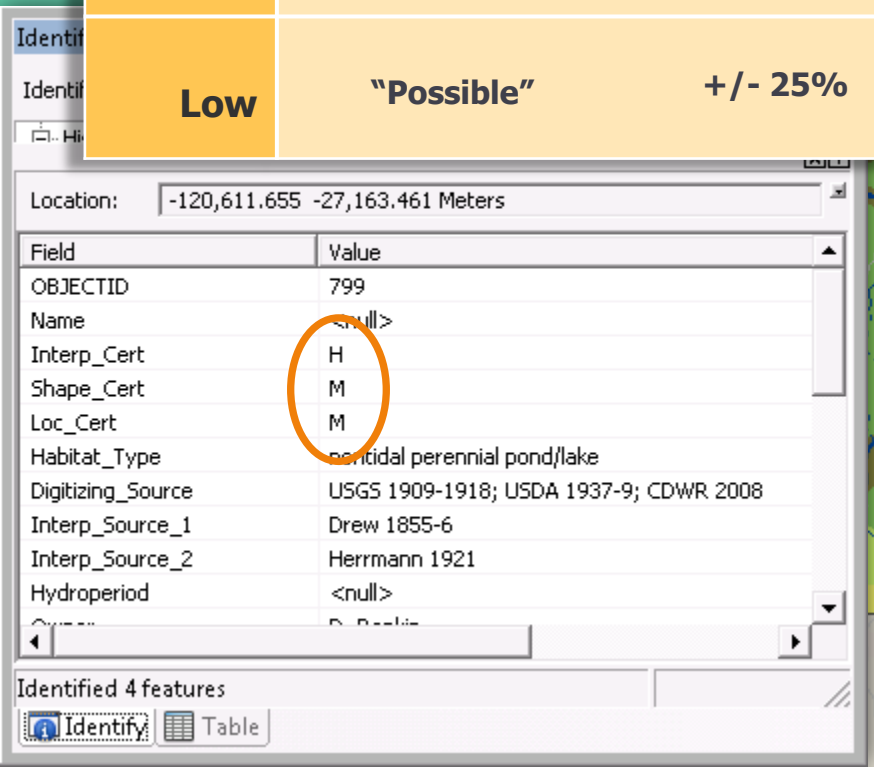
1909-1918

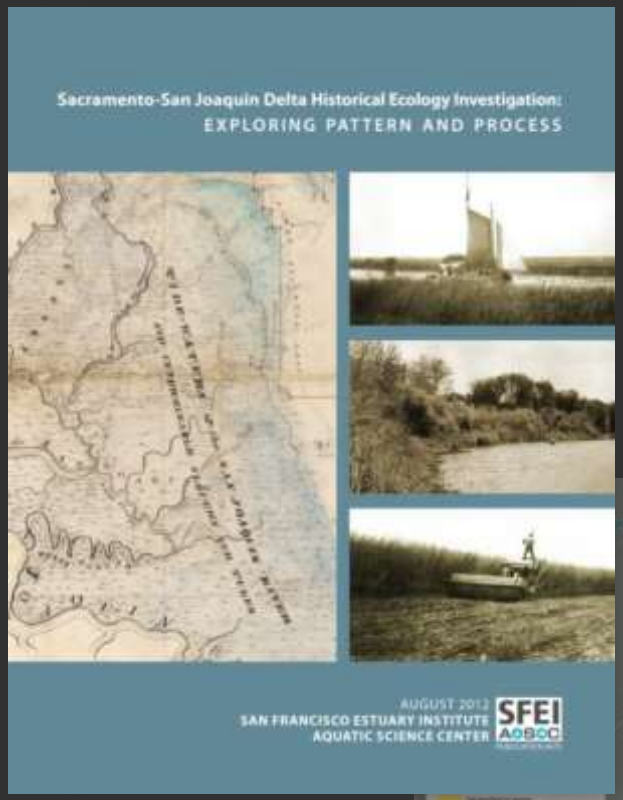
1930

1937

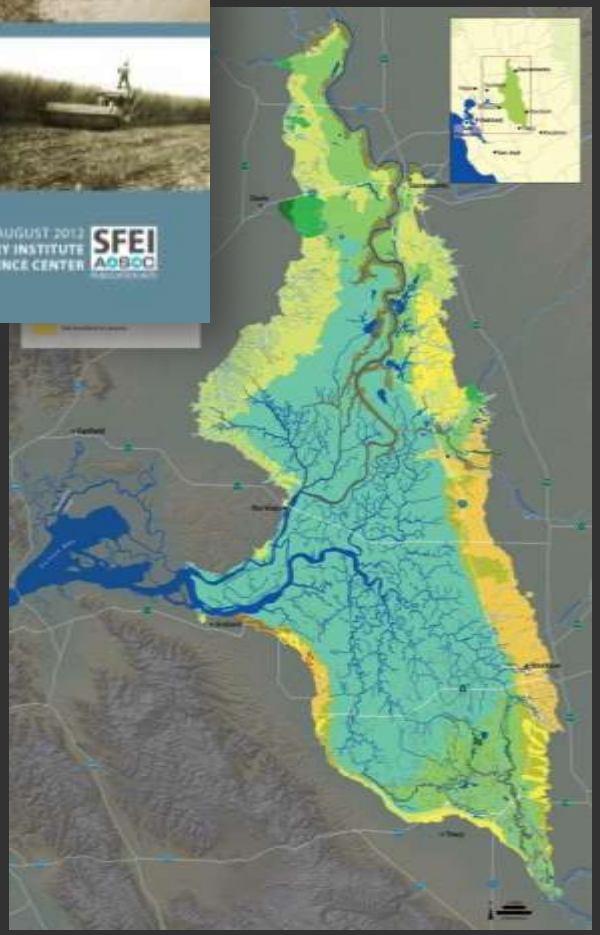
2005

	Interpretation	Size/Shape	Location
High	**"Definite"**	**+/- 10%**	**Within 150 feet**
Medium	**"Probable"**	**+/- 50%**	**Within 500 feet**
Low	**"Possible"**	**+/- 25%**	**Within 2,000 feet**





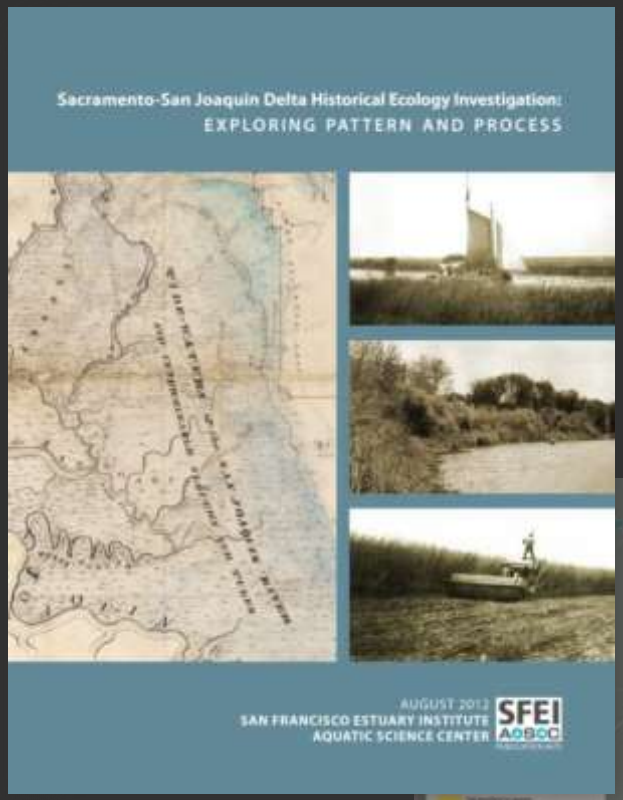
Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process



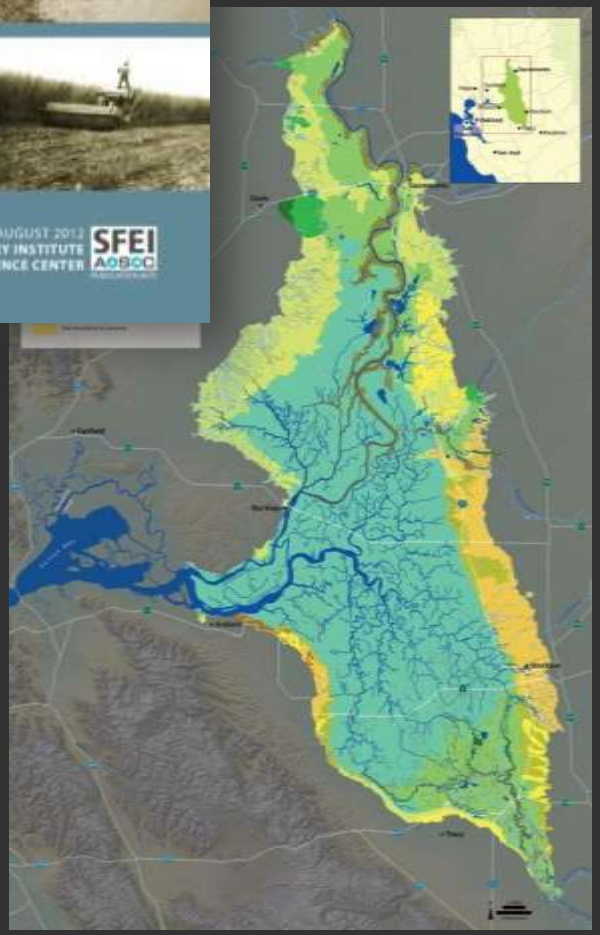
- Funded by Ecosystem Restoration Program (CDFG, NOAA, US FWS)
- Final Report/GIS Available: www.sfei.org/DeltaHEStudy
- Collaboration with KQED QUEST and Stanford's Bill Lane Center for the American West: science.kqed.org/quest/delta-map/

Talk outline

- What is historical ecology and why is it useful?
- How do we do historical ecology?
- Findings of the *Delta Historical Ecology Investigation*
- How is this information being used?



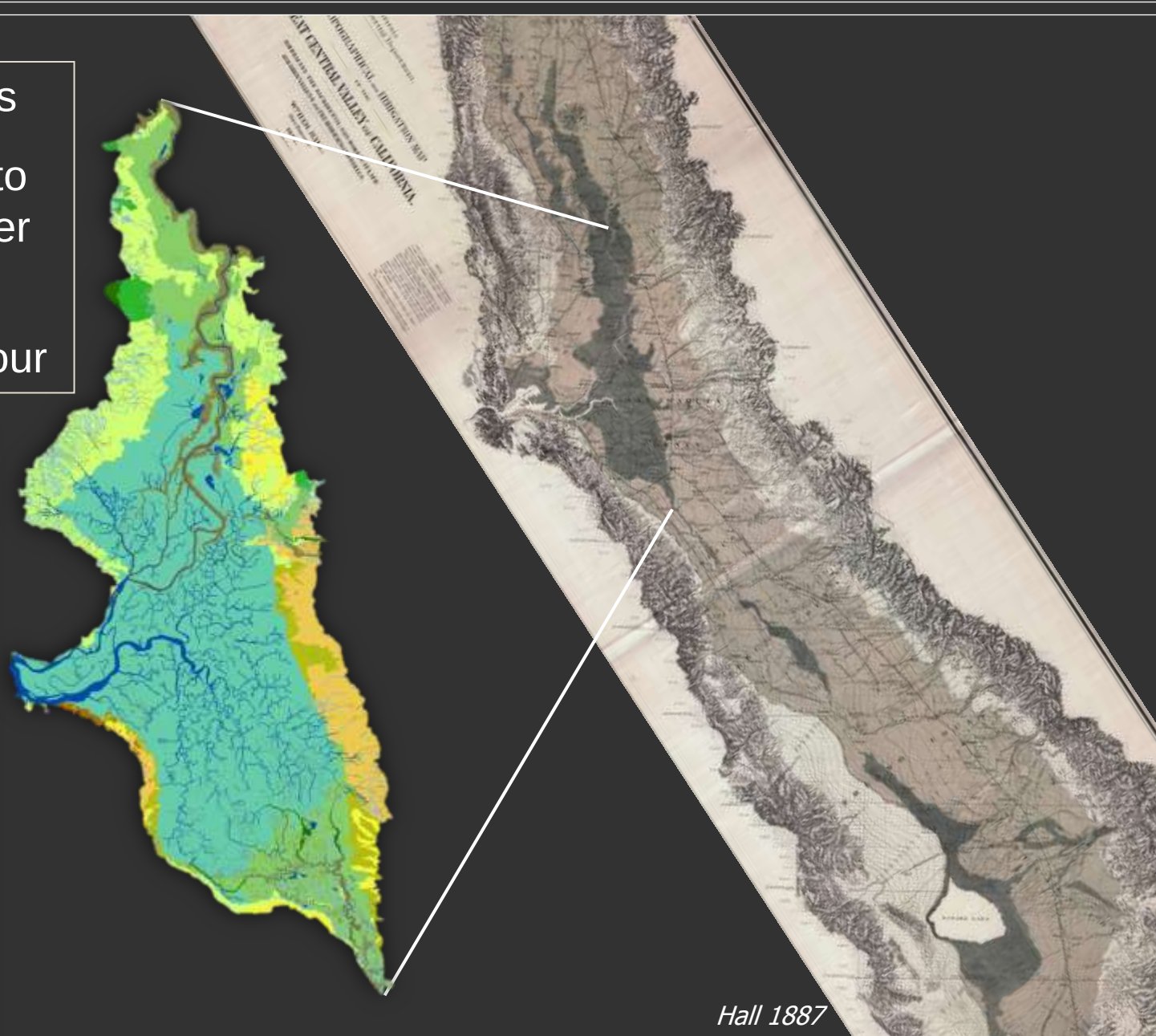
Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process



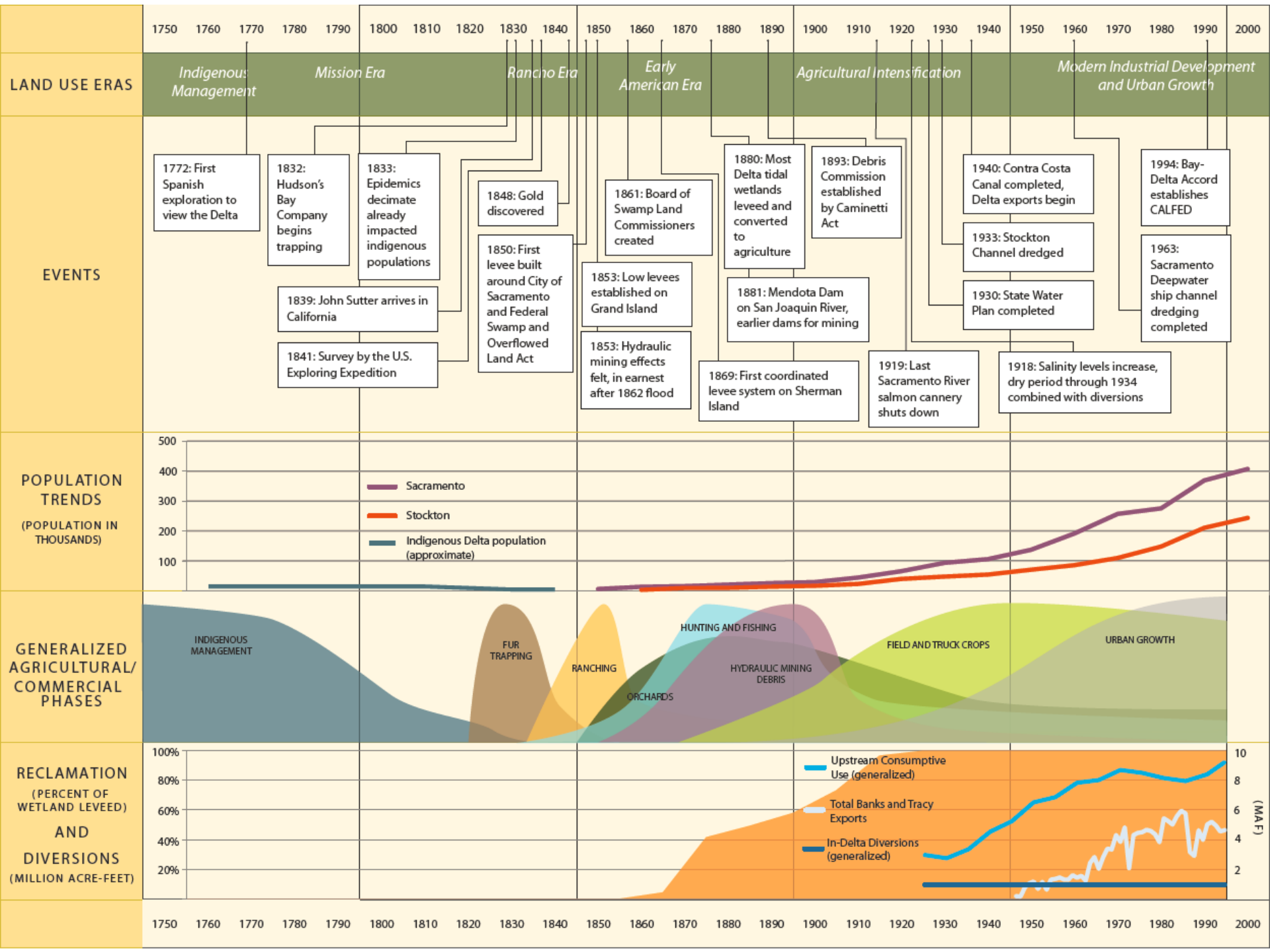
- Funded by Ecosystem Restoration Program (CDFG, NOAA, US FWS)
- Final Report/GIS Available: www.sfei.org/DeltaHEStudy
- Collaboration with KQED QUEST and Stanford's Bill Lane Center for the American West: science.kqed.org/quest/delta-map/

Delta historical ecology study area

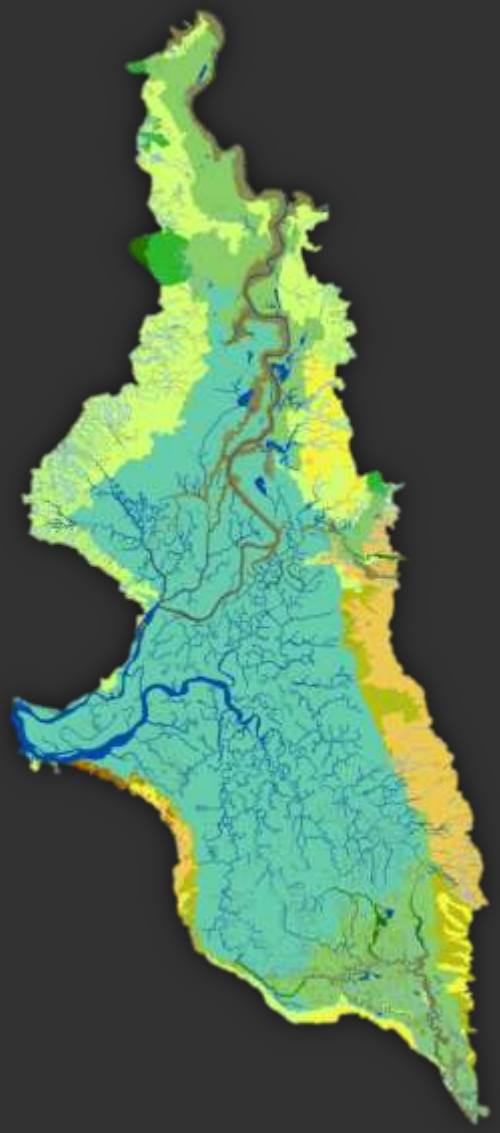
- ~800,000 acres
- Feather River to Stanislaus River
- Within 25-foot elevation contour



Hall 1887

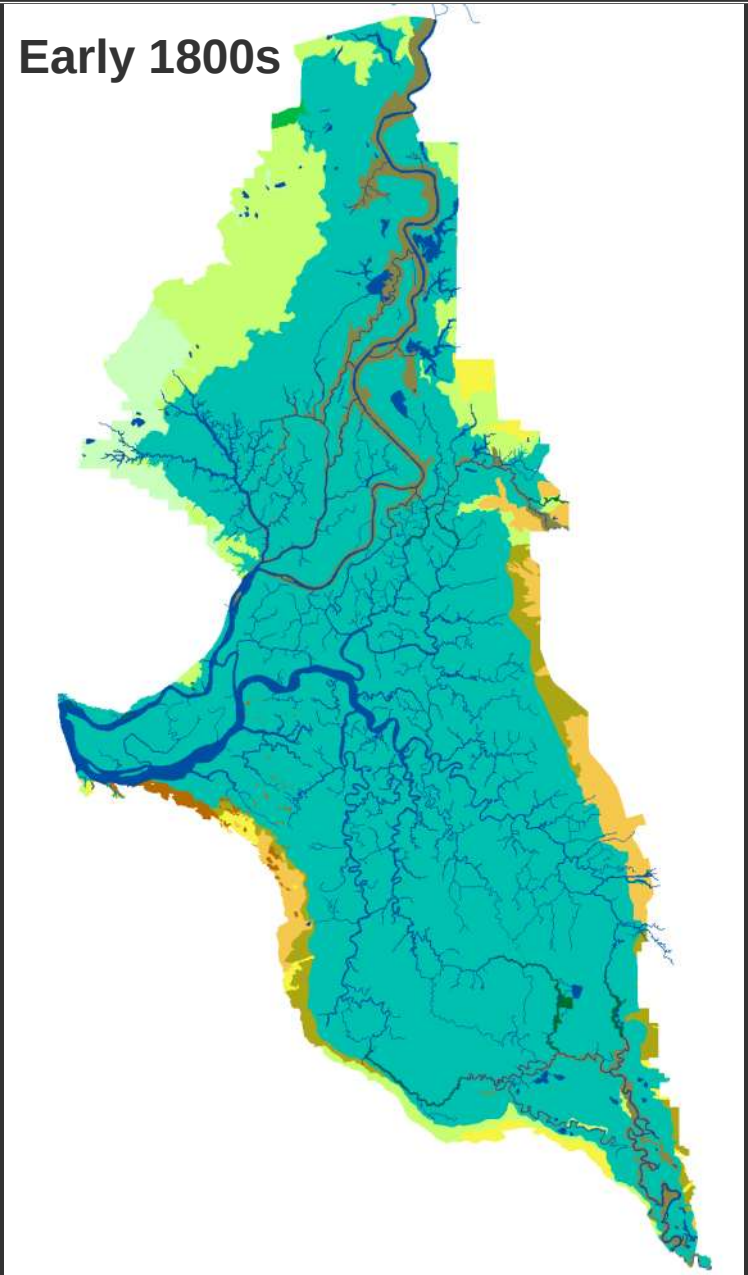

1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
LAND USE ERAS
Indigenous Management
Mission Era
Rancho Era
Early American Era
Agricultural Intensification
Modern Industrial Development and Urban Growth
EVENTS
1772: First Spanish exploration to view the Delta
1832: Hudson's Bay Company begins trapping
1833: Epidemics decimate already impacted indigenous populations
1839: John Sutter arrives in California
1841: Survey by the U.S. Exploring Expedition
1848: Gold discovered
1850: First levee built around City of Sacramento and Federal Swamp and Overflowed Land Act
1853: Low levees established on Grand Island
1853: Hydraulic mining effects felt, in earnest after 1862 flood
1861: Board of Swamp Land Commissioners created
1869: First coordinated levee system on Sherman Island
1880: Most Delta tidal wetlands leveed and converted to agriculture
1881: Mendota Dam on San Joaquin River, earlier dams for mining
1893: Debris Commission established by Caminetti Act
1919: Last Sacramento River salmon cannery shuts down
1930: State Water Plan completed
1933: Stockton Channel dredged
1940: Contra Costa Canal completed, Delta exports begin
1918: Salinity levels increase, dry period through 1934 combined with diversions
1963: Sacramento Deepwater ship channel dredging completed
1994: Bay-Delta Accord establishes CALFED
POPULATION TRENDS
(POPULATION IN THOUSANDS)
500
400
300
200
100
Sacramento
Stockton
Indigenous Delta population (approximate)
GENERALIZED AGRICULTURAL/ COMMERCIAL PHASES
INDIGENOUS MANAGEMENT
FUR TRAPPING
RANCHING
ORCHARDS
HUNTING AND FISHING
HYDRAULIC MINING DEBRIS
FIELD AND TRUCK CROPS
URBAN GROWTH
RECLAMATION
(PERCENT OF WETLAND LEVEED)
AND
DIVERSIONS
(MILLION ACRE-FEET)
100%
80%
60%
40%
20%
Upstream Consumptive Use (generalized)
Total Banks and Tracy Exports
In-Delta Diversions (generalized)
10
8
6
4
2
(MAF)
1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000

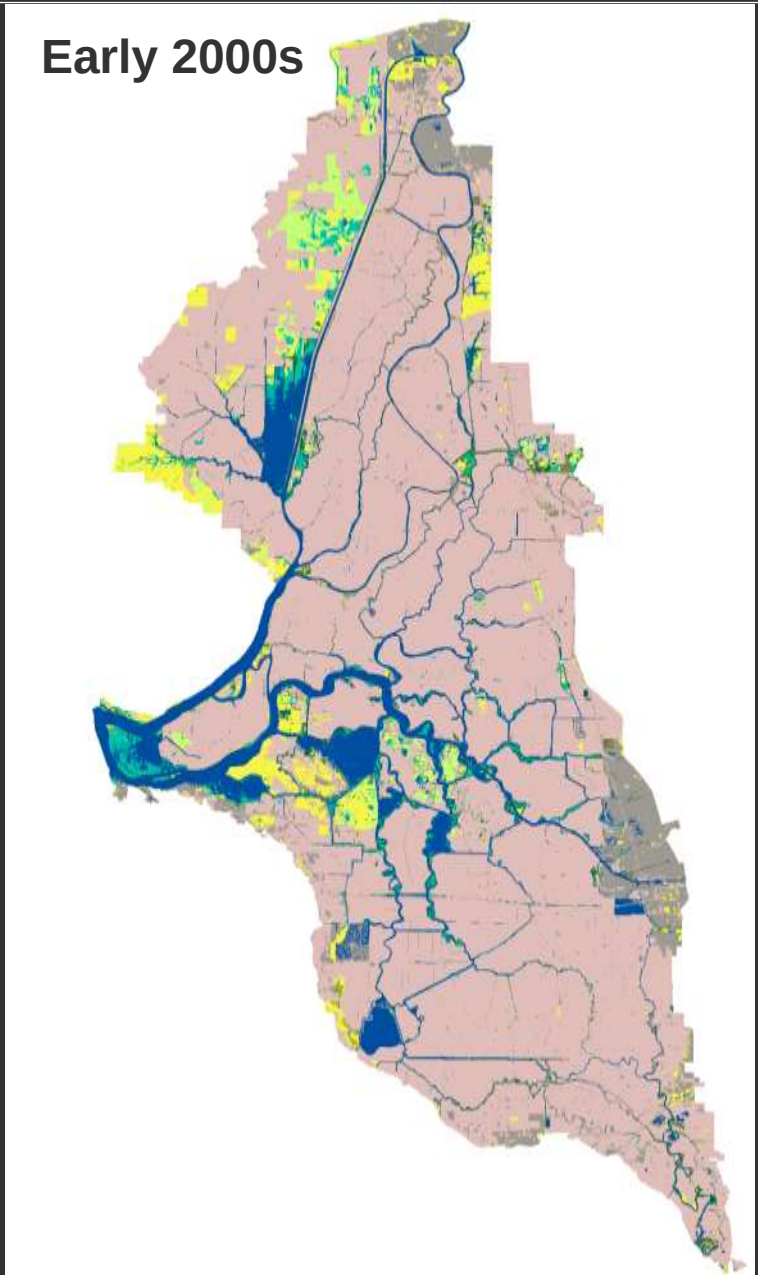
Findings: historical mapping



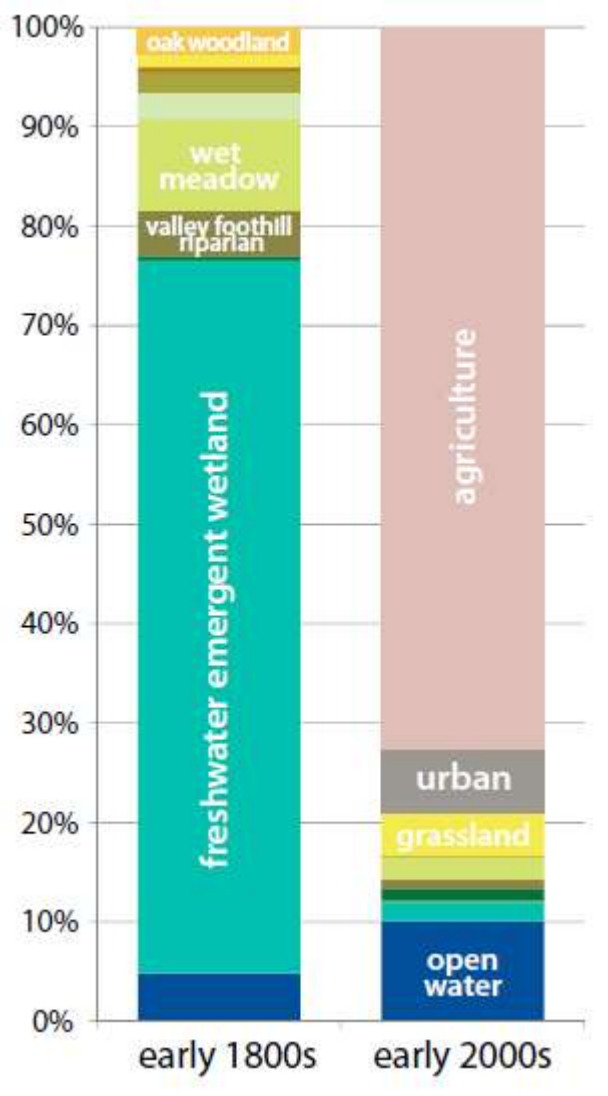
- Relative wetness
  - Tidal = 395,000 acres (50%)
  - Wet year-round = 124,000 acres (16%)
  - Seasonal wetlands = 144,000 acres (18%)
- Tidal channels
  - 1,600 miles, >26,700 acres
  - Small tidal channels were 73% of total length
- Lakes and ponds
  - 83 individual features (>5 acres) within the wetlands equaling >5,700 acres
- Freshwater wetlands
  - 365,000 acres tidal, 113,000 acres non-tidal
- Riparian forest and willow
  - 42,600 acres of forest, 8,800 of willow thickets
- Seasonal wetlands
  - 143,000 acres of wet meadow, vernal pool, and alkali wetland

Land cover change



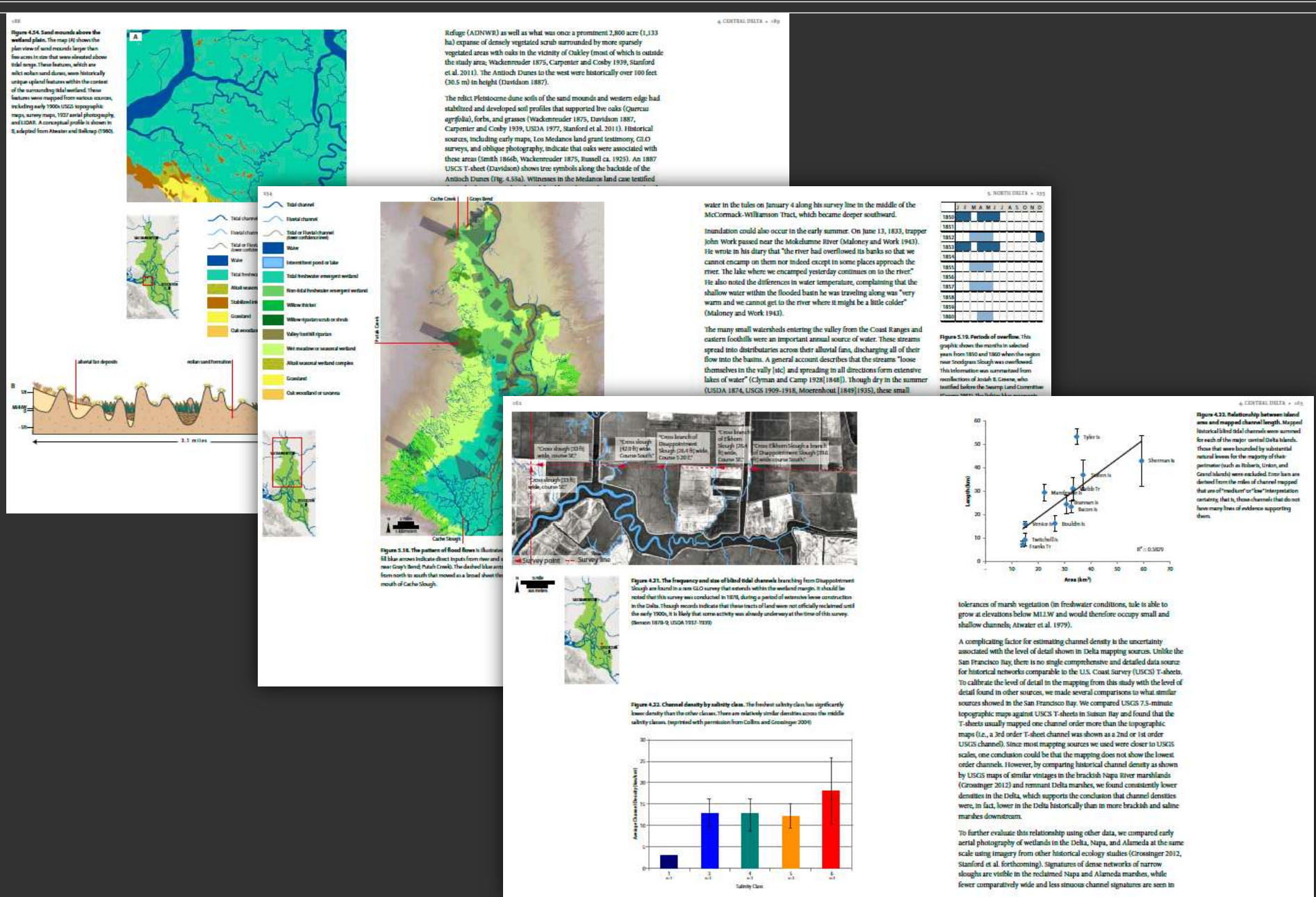


Land cover change



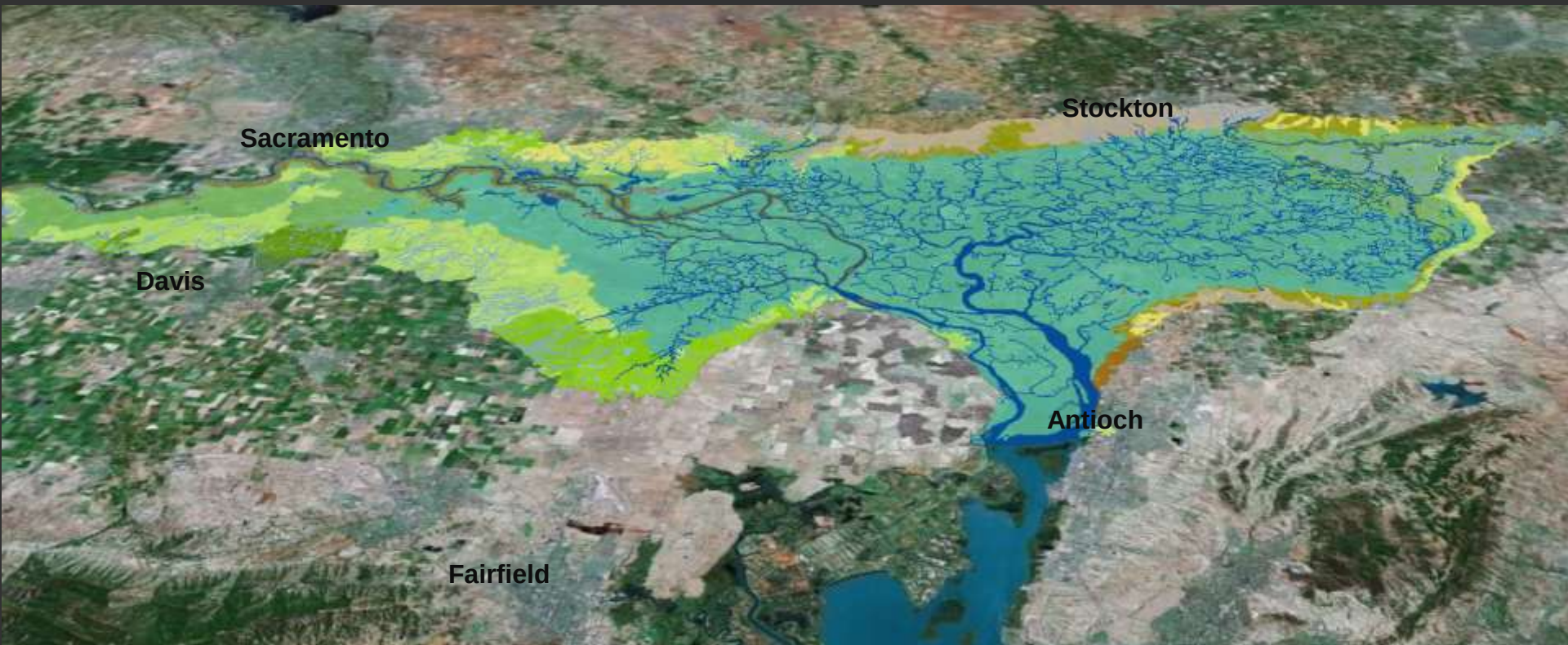
- 3% of historical freshwater wetlands remain
- Ratio of open water to freshwater wetland
  - Historically: 7:100
  - Today: 556:100
- Open water now in central Delta instead of as lakes within wetlands upstream
- 81% loss of small tidal channels
- Few true “remnants”
- Highly fragmented natural habitats

Landscape pattern and process

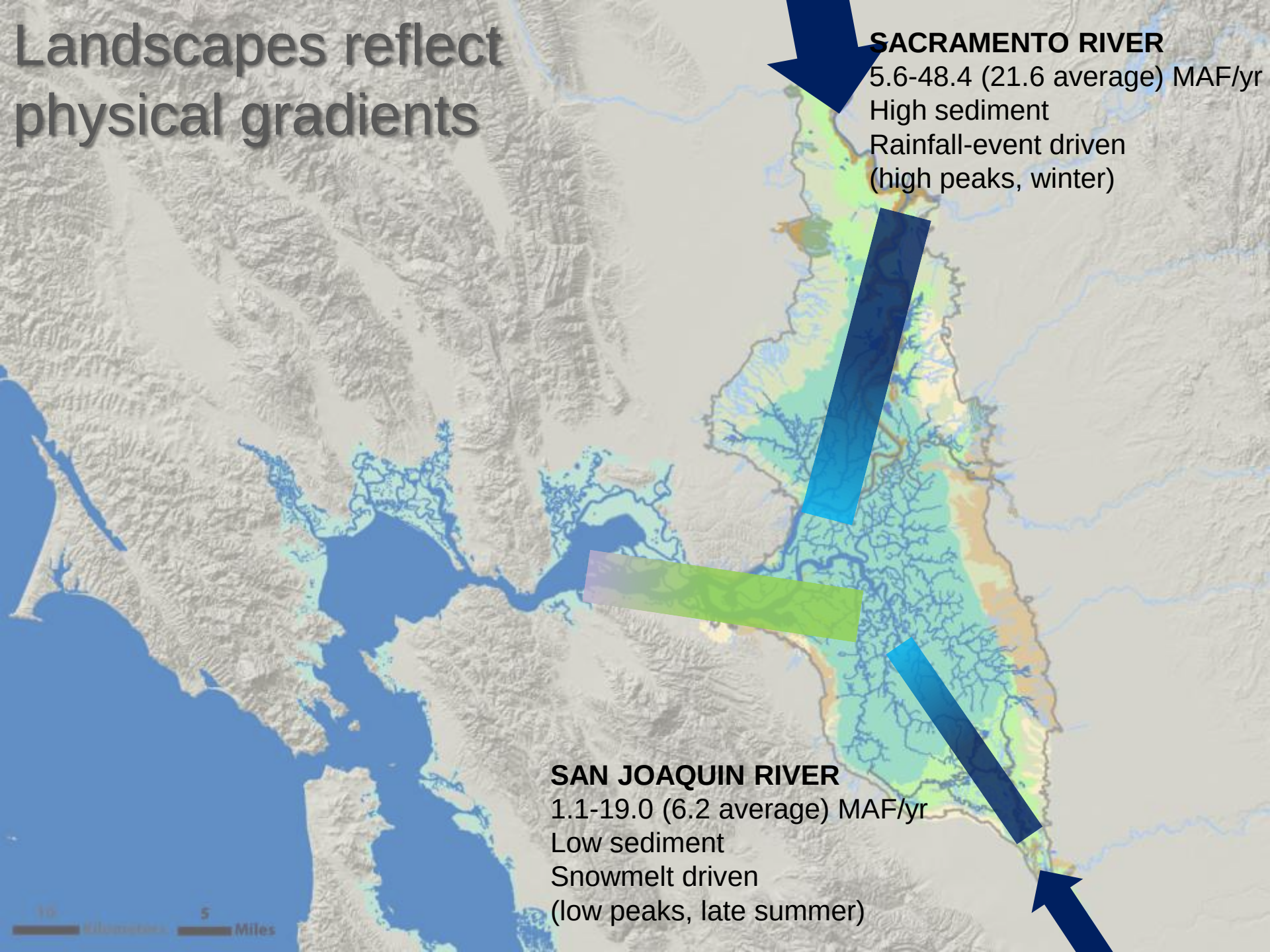


Key points

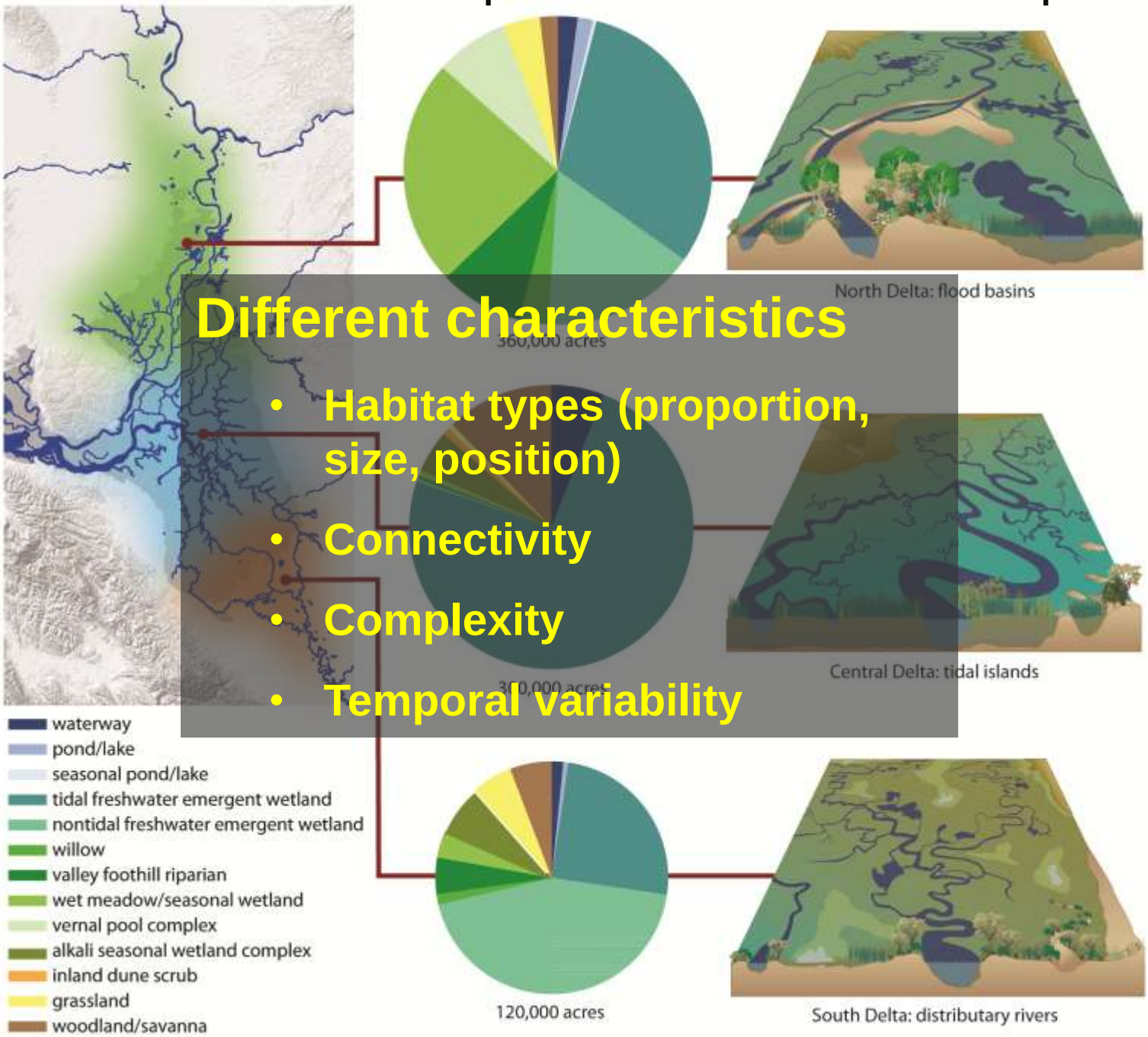
- Multiple landscapes
  - Habitat mosaics arranged in distinct patterns
  - Expressed across broad physical gradients



Landscapes reflect physical gradients



Conceptual models of historical landscapes



Different characteristics

- Habitat types (proportion, size, position)
- Connectivity
- Complexity
- Temporal variability

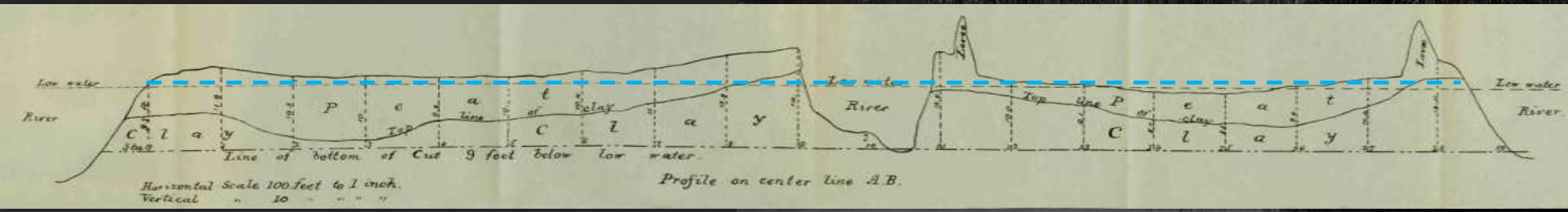
Central Delta: where tides dominate

Central Delta: where tides dominate

- Low banks
- Frequent tidal inundation
- High connectivity between land and water

"The water reached our blankets at the turn of the tide"

- October 1811, Abella and Cook 1960



Gilbert 1905

Central Delta: where tides dominate

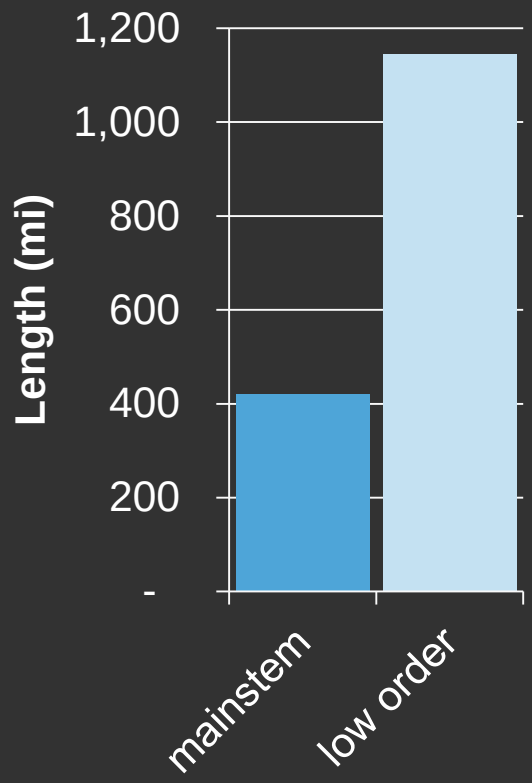
- Numerous sinuous tidal channels of different sizes

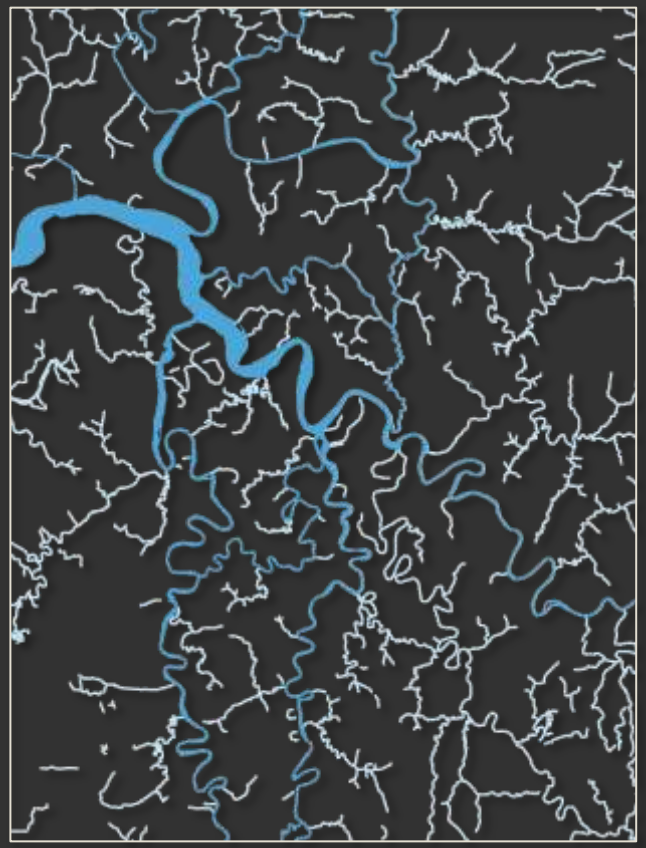
*"The **number and intricacy** of the winding sloughs and channels that traverse this…low marshy land is worthy of notice."*

- US War Department 1853

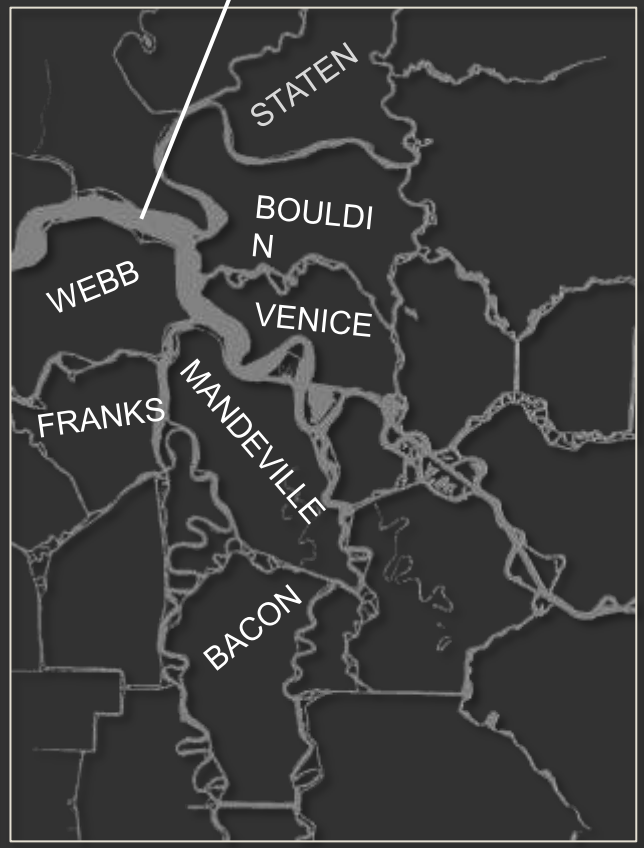
Central Delta: where tides dominate

- Numerous sinuous tidal channels of different sizes
- Organized into networks branching into wetland





early 1800s



early 2000s

Central Delta: where tides dominate

CAUSED BY "CUTS".

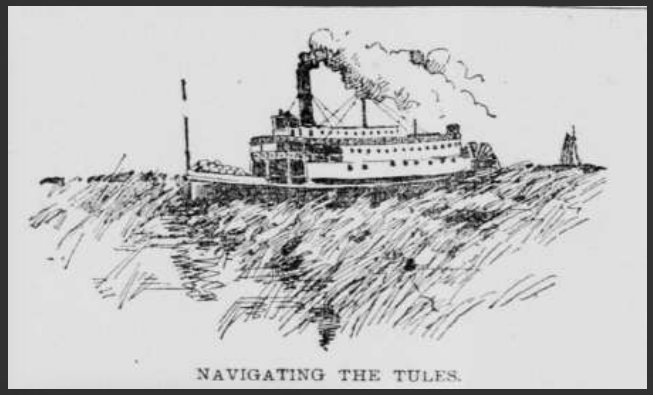
The San Joaquin Almost Unnavigable.

EXCEPT AT HIGH TIDE.

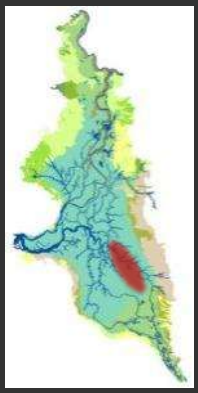
Unexpected Result of Shortening the River.

In the old days, when the river twisted like a snake, the rise and fall of the tide in the bay did not make a difference in the San Joaquin between Stockton and Twenty-one Mile Slough of more than two feet. The reason of this was that the many curves in the stream prevented the water running out as fast as the tide fell. By the time the tide had fallen six feet in the bay the water fell only two feet in the river, and when the tide rose in the bay it caught the flood and the river commenced to rise again. By this natural phenomenon the river was navigable at all hours.

"But now things have changed," said Pilot Arthur Robinson yesterday, "and the water runs through those cuts at low tide as it would out of a tin pan. The tide



NAVIGATING THE TULES.



"In the old days, when the river twisted like a snake, the rise and fall…did not make a difference…of more than two feet."

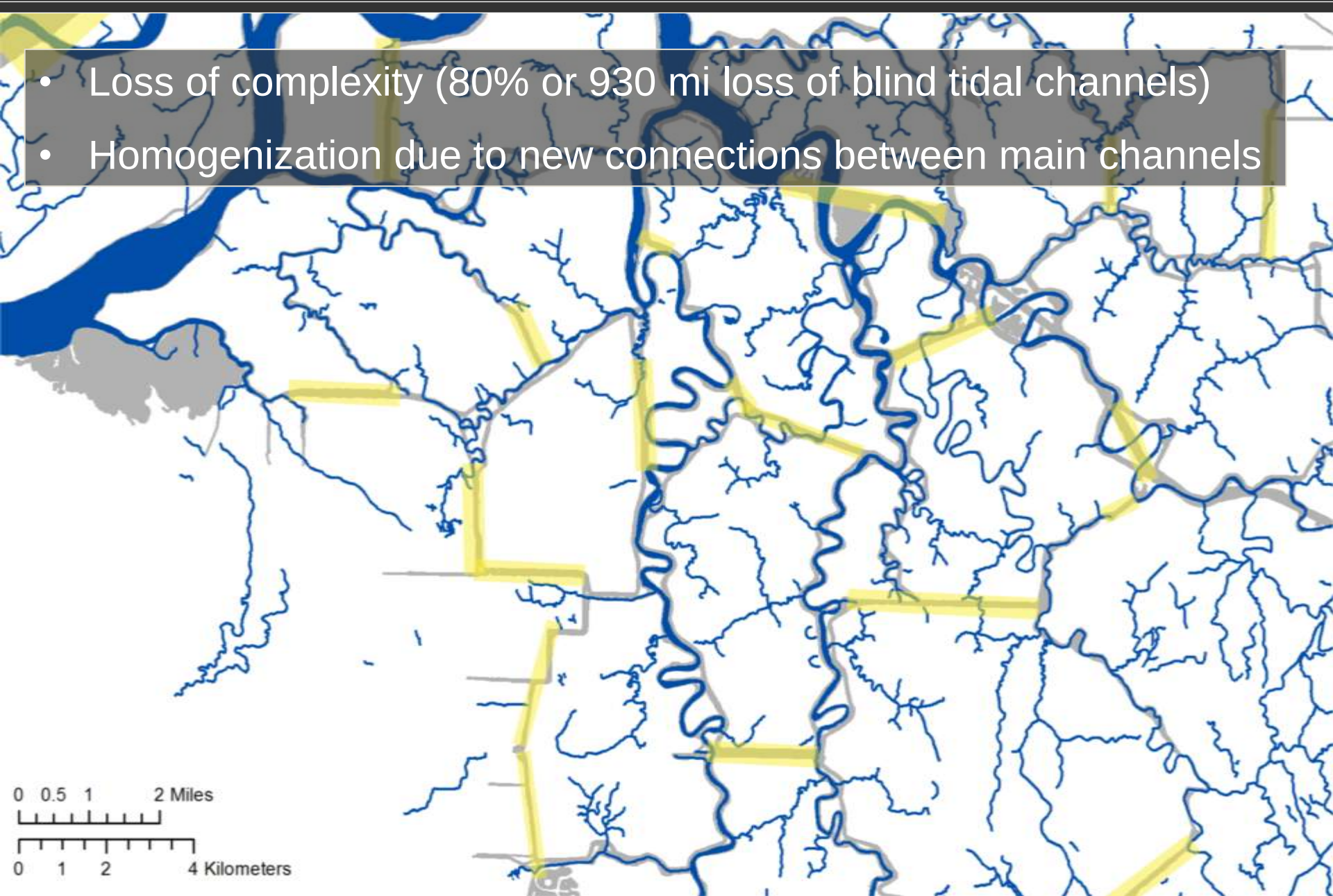
"...the many curves…prevented the water running out as fast as the tide fell."

"…the river was navigable at all hours."

"…now things have changed…the water runs through those cuts…as it would out of a tin pan."

The Morning Call, September 19, 1894

Central Delta: where tides dominate



Central Delta: where tides dominate

- Diverse vegetation community including willow-fern swamp

ITEM REMOVED DUE TO COPYRIGHT STATUS

Comparing the central Delta to the north Delta:

"Interior parts the tule is thinner and shorter. Willows here grow in bunches…"

- USDA 1874

Gibbes 1850, courtesy of UC Davis Shields Library

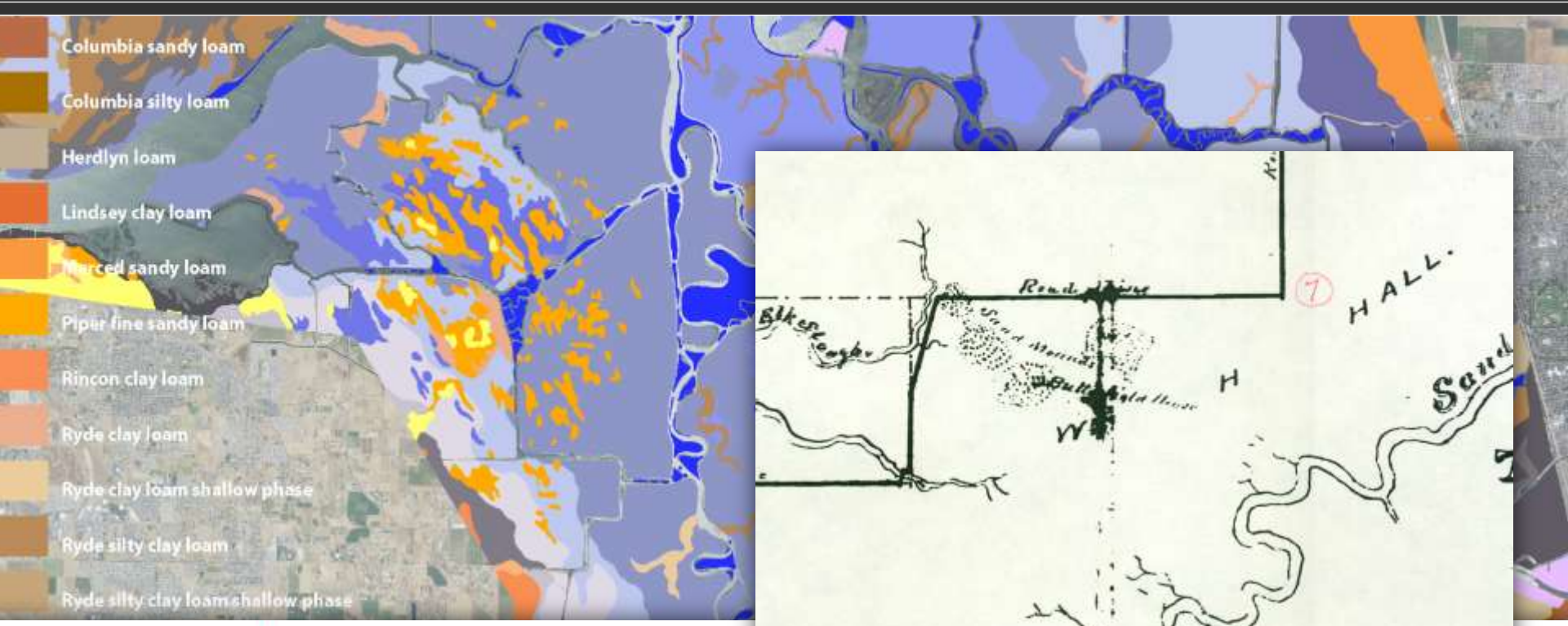
Central Delta: where tides dominate

- Diverse vegetation community including willow-fern swamp

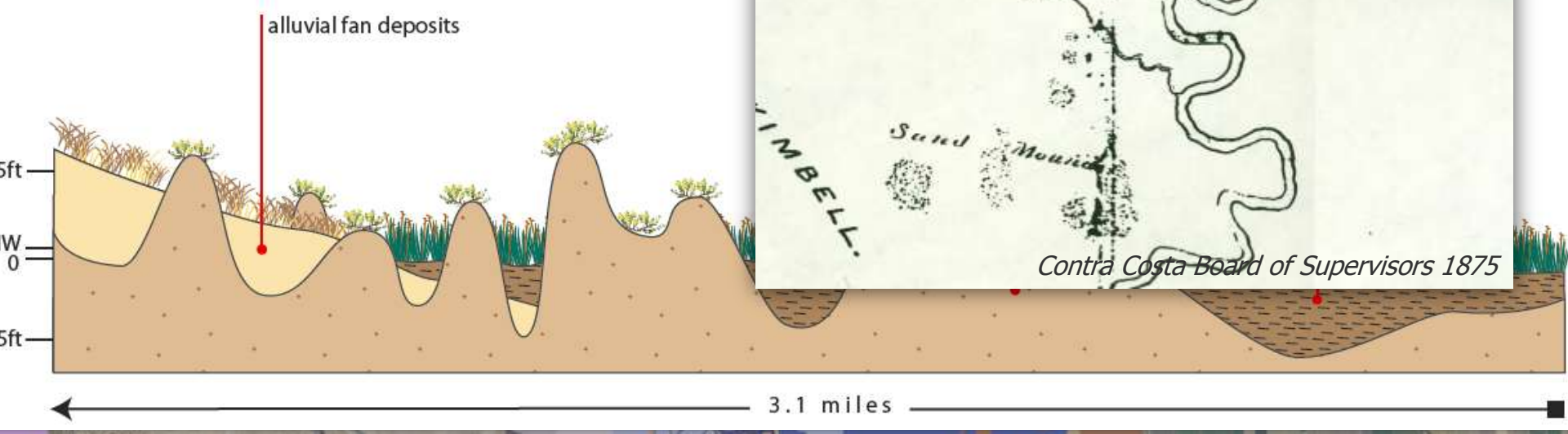
ITEM REMOVED DUE TO COPYRIGHT STATUS

Photo by Daniel Burmester

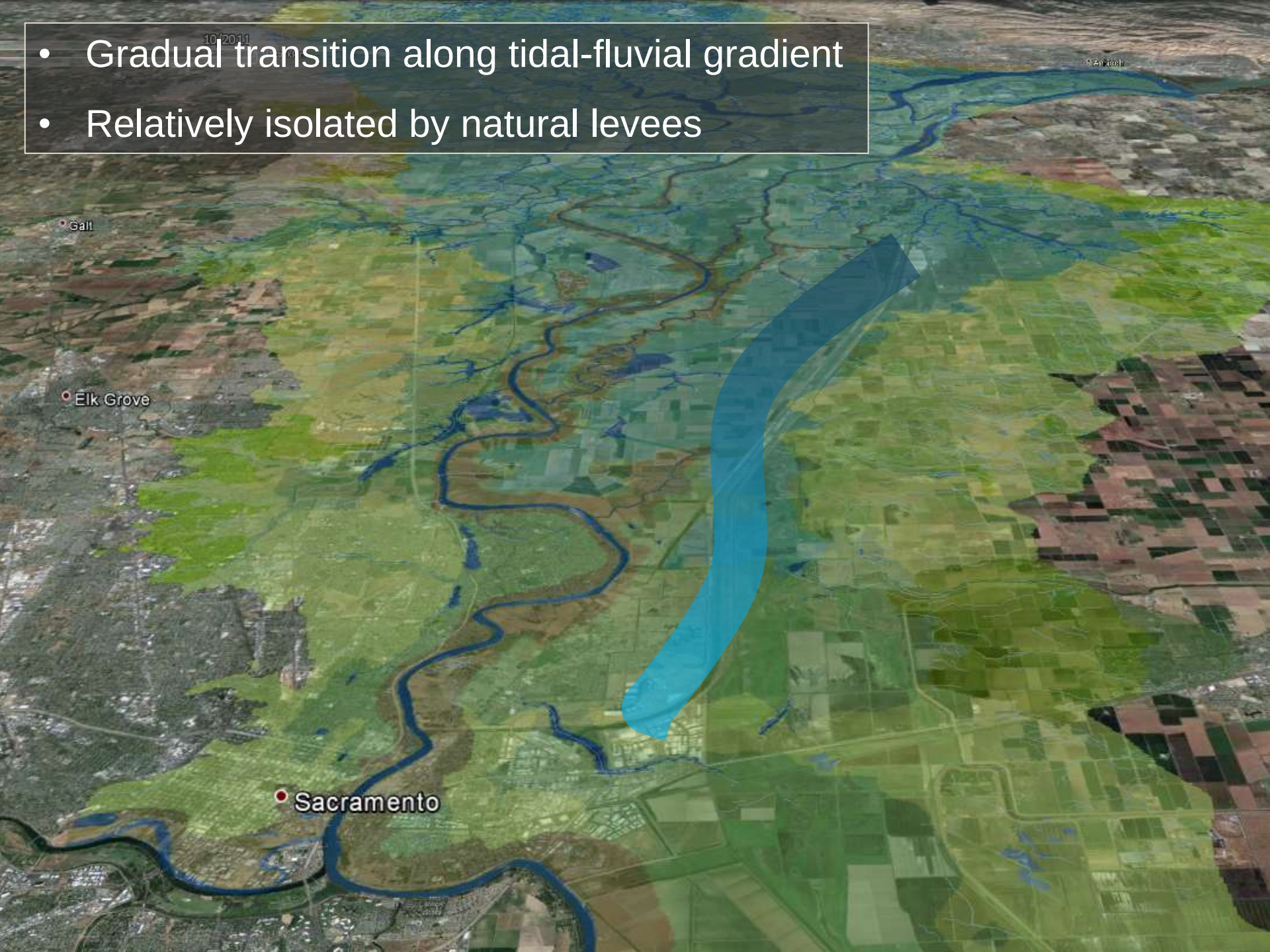
Central Delta: where tides dominate



Contra Costa Board of Supervisors 1875



North Delta: where flood basins flank rivers

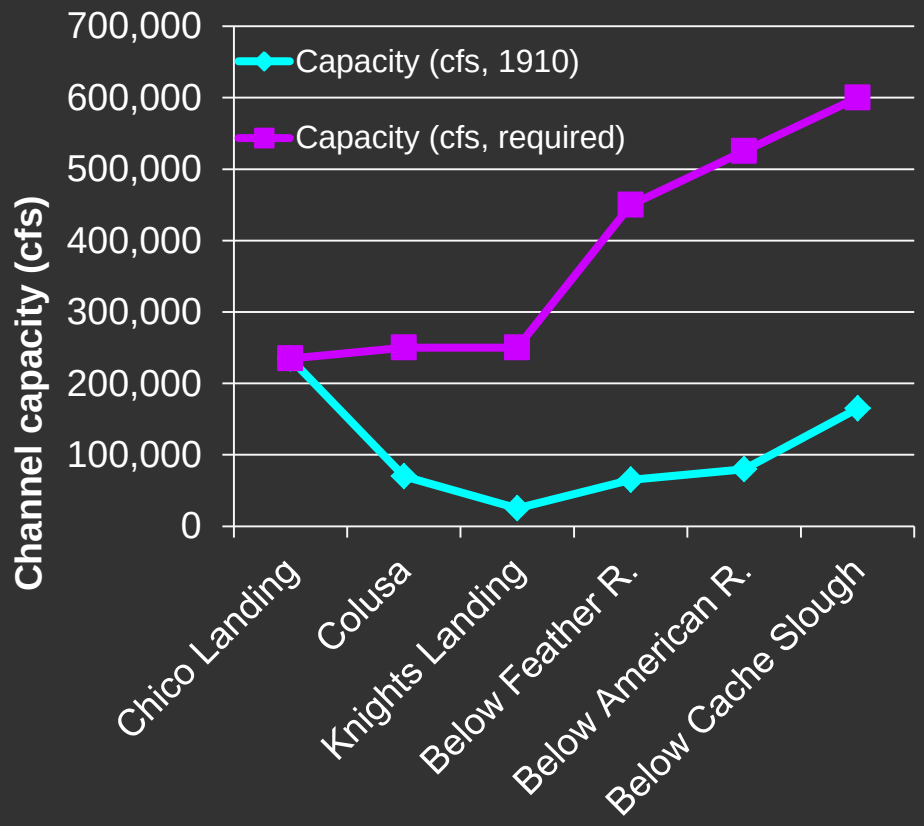


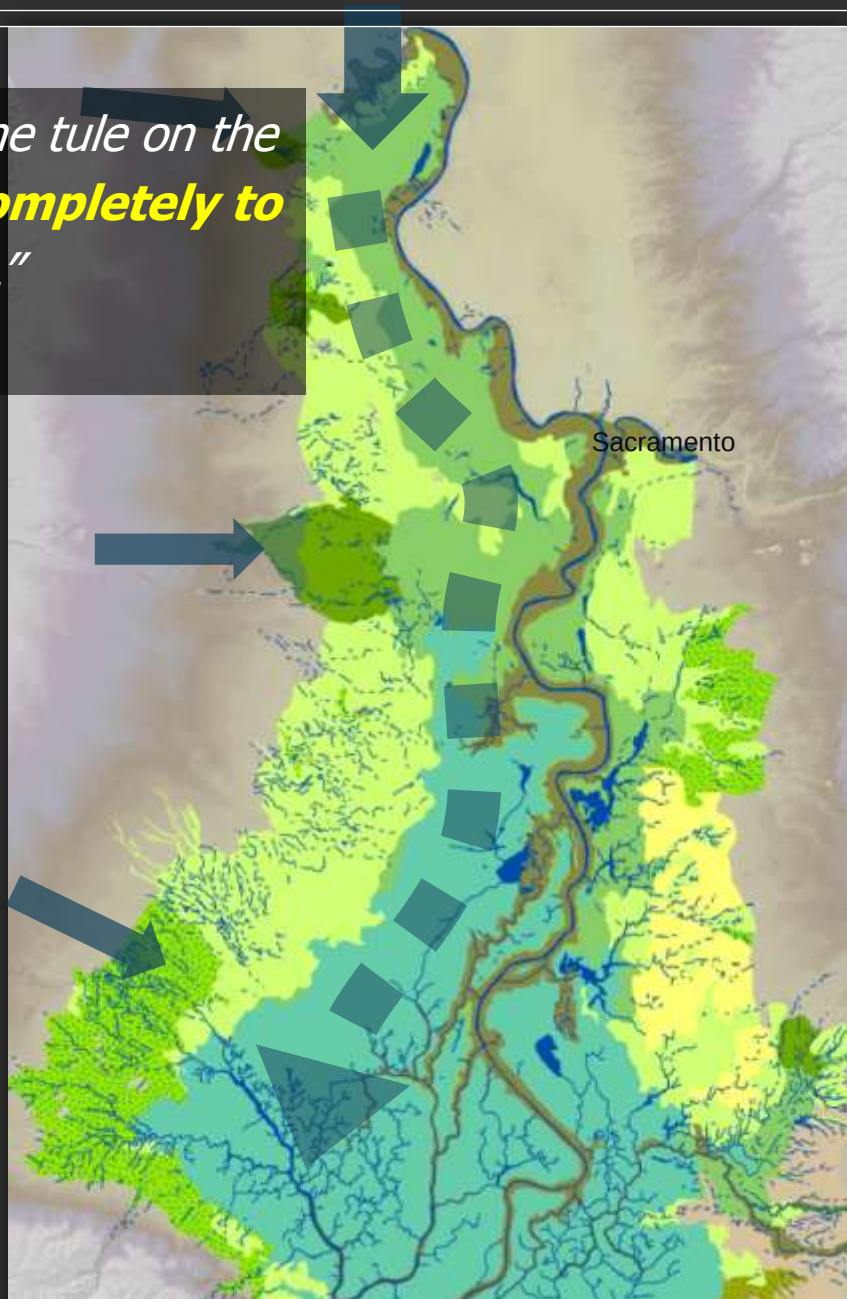
- Gradual transition along tidal-fluvial gradient
- Relatively isolated by natural levees

North Delta: where flood basins flank rivers

*"...the water pours down Cache slough from the tule on the west in such volume and with such force as **completely to neutralize the current** in Steamboat slough."*

- Sacramento Daily Union, 24 March 1862



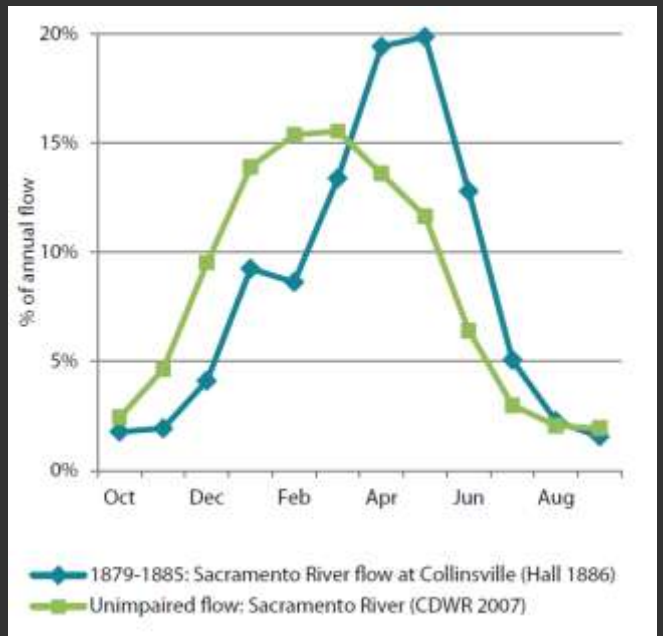


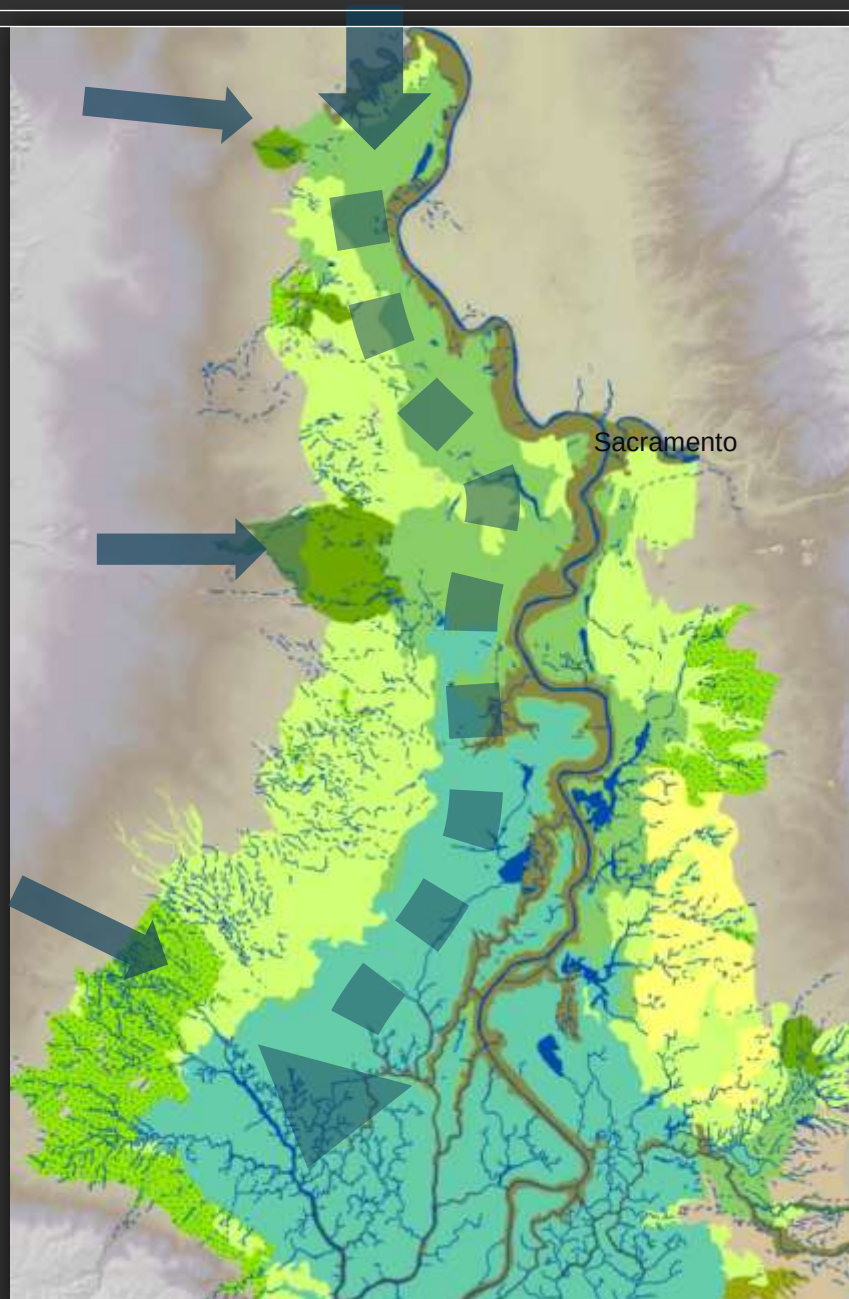
North Delta: where flood basins flank rivers

- Basins attenuated flood flows
- Floods connected components

*"the great basins…act as **enormous regulating reservoirs**…to cut down the crest of the great flood waves"*

- Dabney Commission 1905



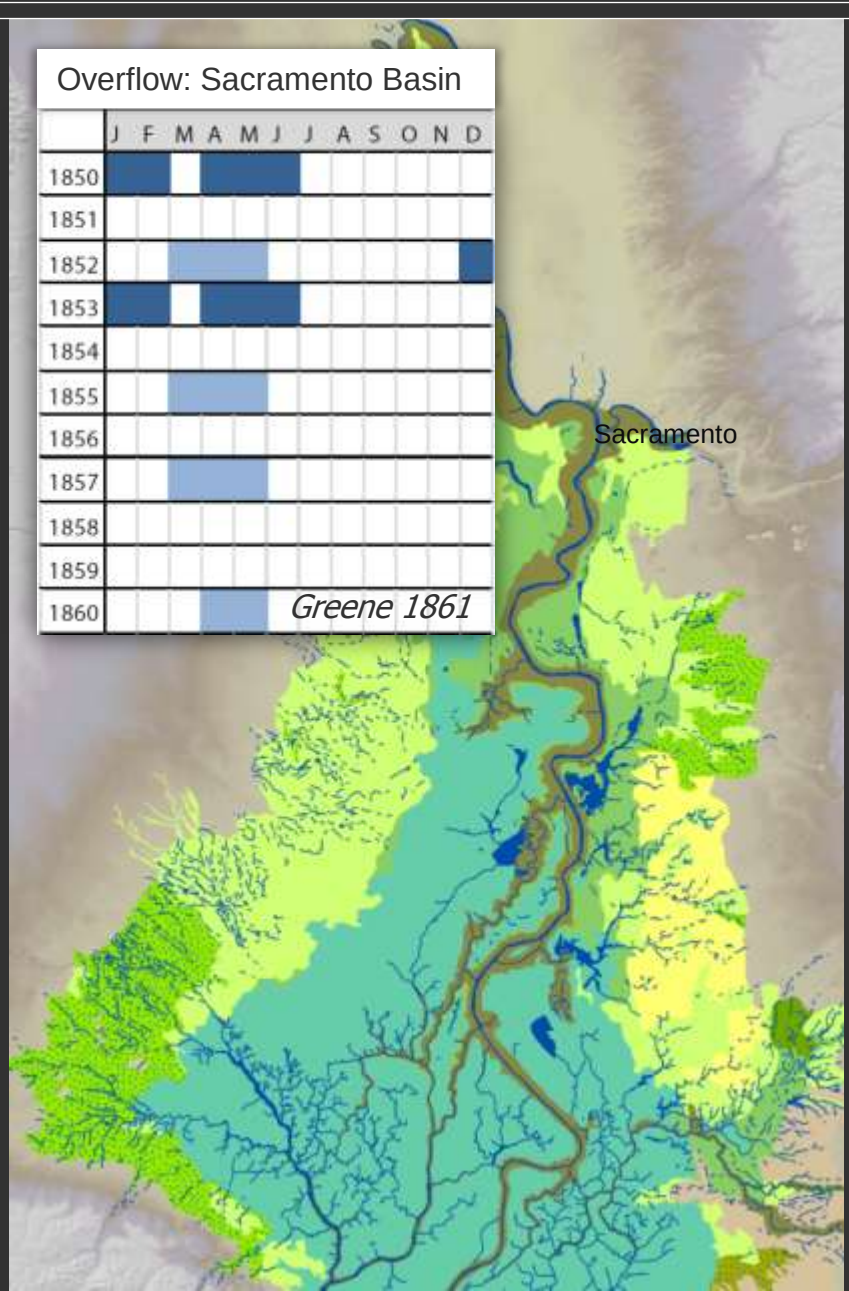


North Delta: where flood basins flank rivers

- Wet late into summer
- Seasonal and inter-annual variability

*"…**creeping slowly** along toward tide water, **not in a direct or free channel**… thoroughly saturated with water until later in the summer months"*

- Board of Swamp Land Commissioners 1864



North Delta: where flood basins flank rivers

- Tidal to fluvial gradient = tidal channels to lakes

ITEM REMOVED DUE TO COPYRIGHT STATUS

Courtesy of Solano County Surveyor

Courtesy of California State Library

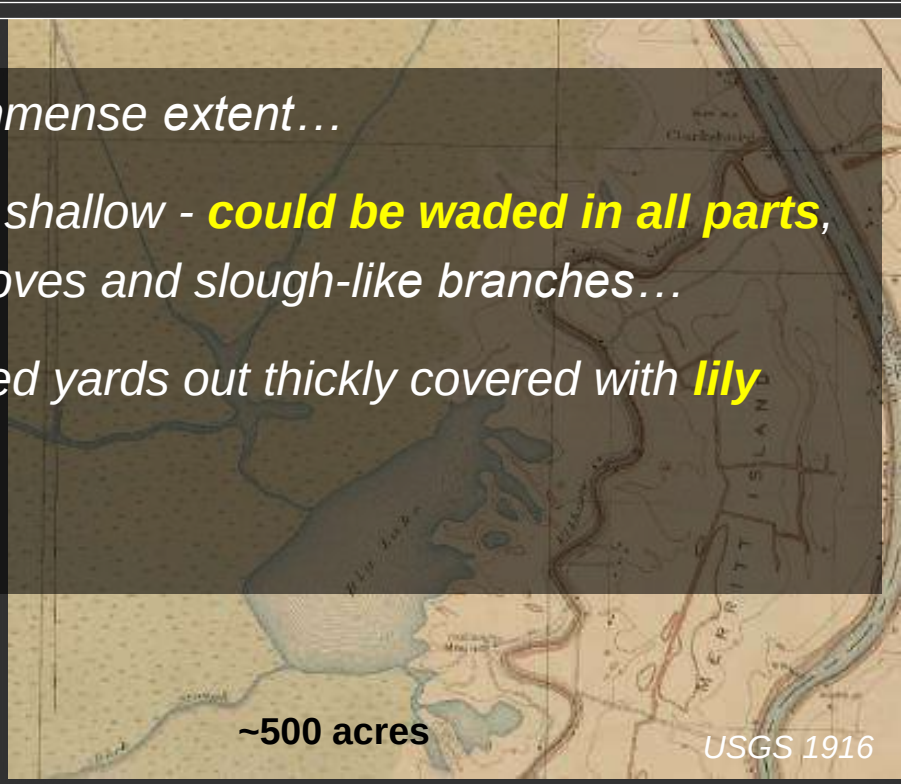
North Delta: where flood basins flank rivers

"Far out in an impenetrable tule swamp of immense extent…

*Though the lake was a large one it was very shallow - **could be waded in all parts**, except a small streak in the middle...many coves and slough-like branches…*

*Edge of the lake for a distance of one hundred yards out thickly covered with **lily pads**."*

- Wright ca. 1850



~500 acres

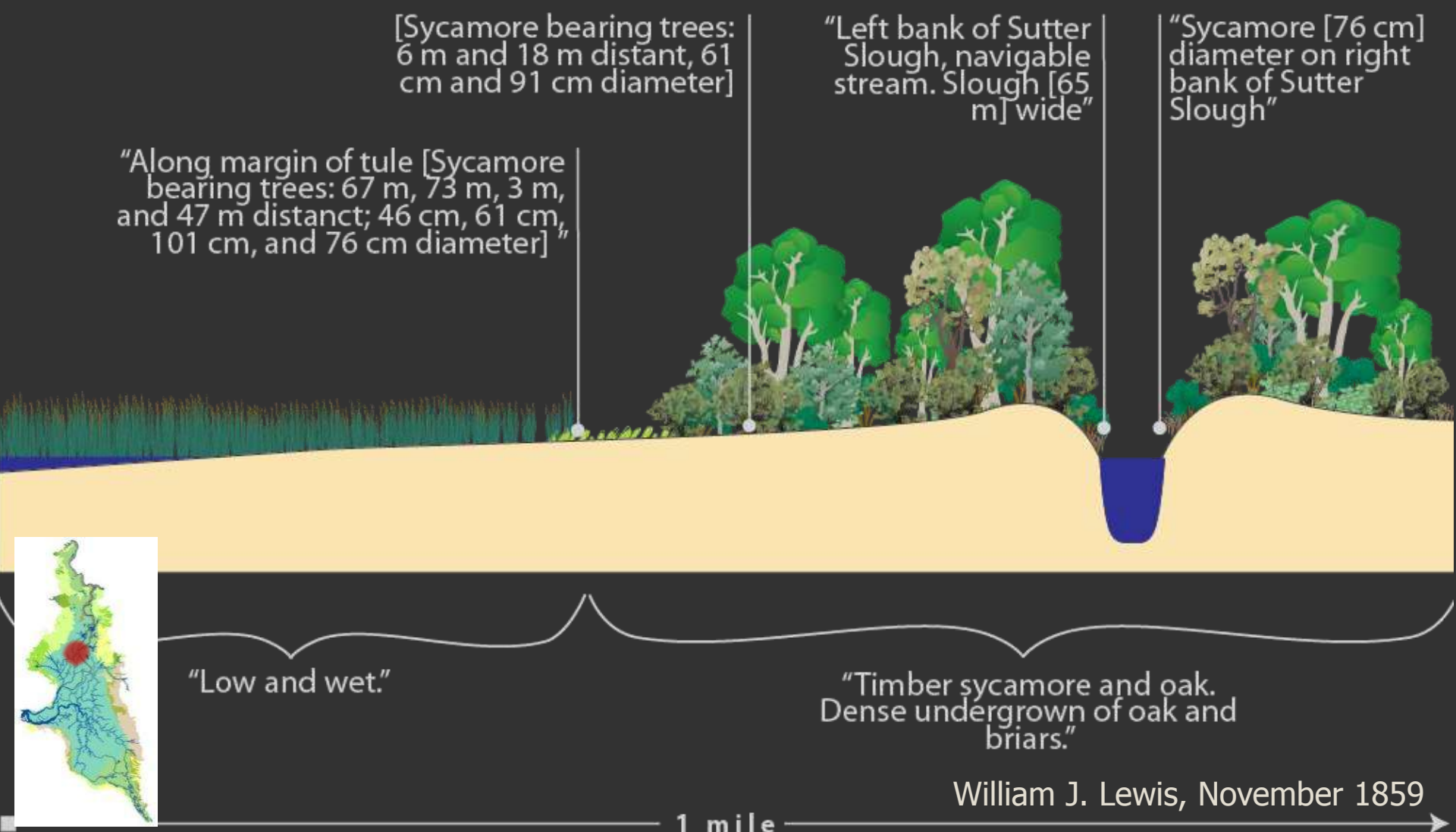
USGS 1916

North Delta: where flood basins flank rivers

- Dense and structurally complex riparian forest

North Delta: where flood basins flank rivers

- Riparian forest on natural levees bounded flood basins



Gilbert 190

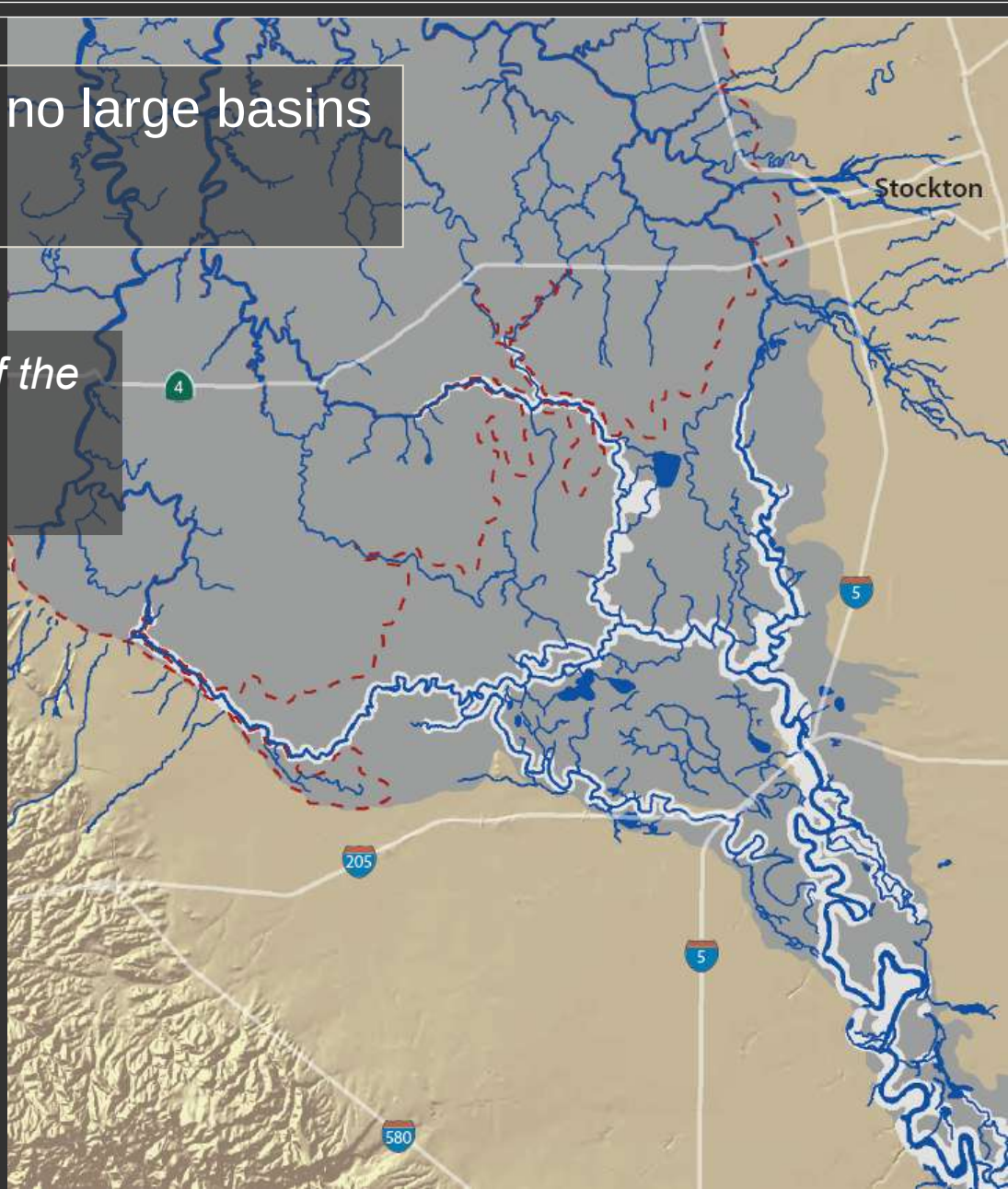
South Delta: where floodplains meet tides

South Delta: where floodplains meet tides

- Broadening floodplain with no large basins
- Wet late into summer

"Inundated during the high water of the rivers, which is in the summer."

- Viader 1810



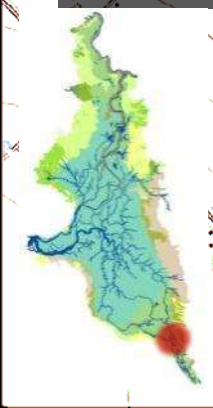
Approaching the San Joaquin Crossing (near I-5 today):

*"There were more **ponds, swamps and sloughs**…The first of these places had about three feet of water, but the bottom was solid and we crossed it without difficulty. The second was a slough more than fifty meters long where one went at random…The third was a little lake.*

*There we were lucky enough to find a **balsa of tules** or an immense bundle of reeds or bullrushes tied together, **on which we took over our saddles, our baggage and ourselves**.*

Towards two o'clock we reached the lagoon where an American had perished a few days before."

- Jacques Moerenhout, July 13, 1848

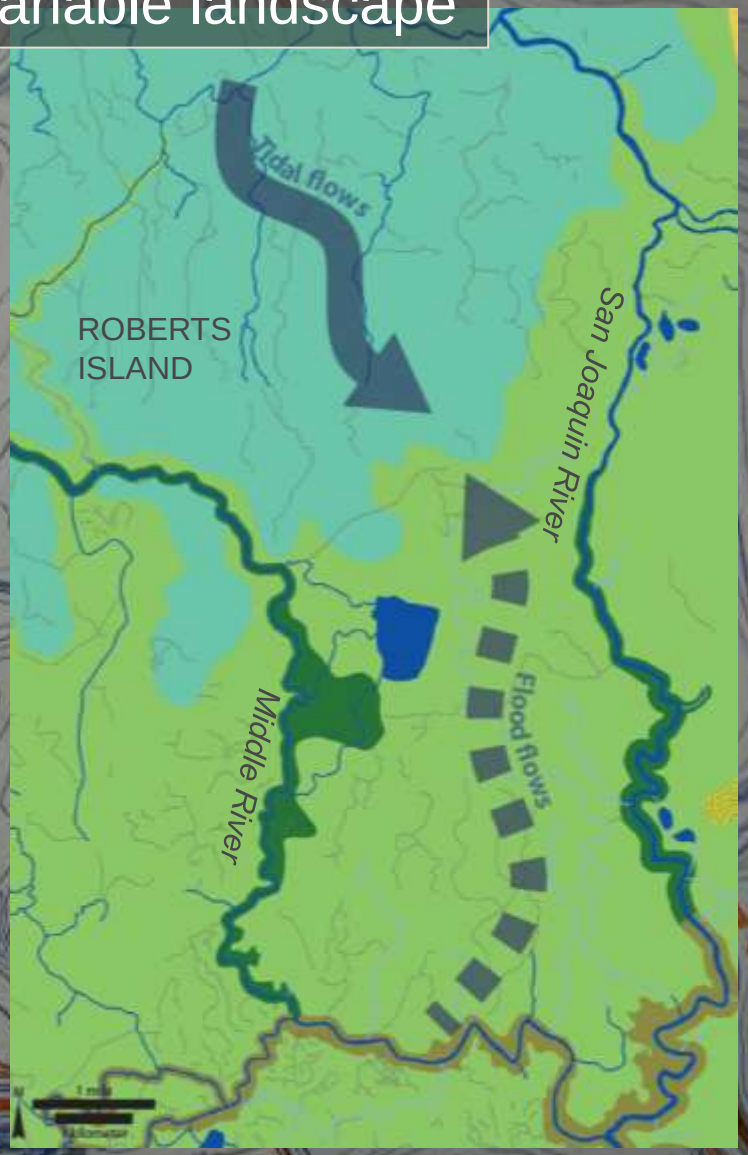


South Delta: where floodplains meet tides

- Complex flows across topographically variable landscape

*"These discharge into **small lakes or spread out** in the tule, and are **drained off by the slues**"*

- Gibbes 1850

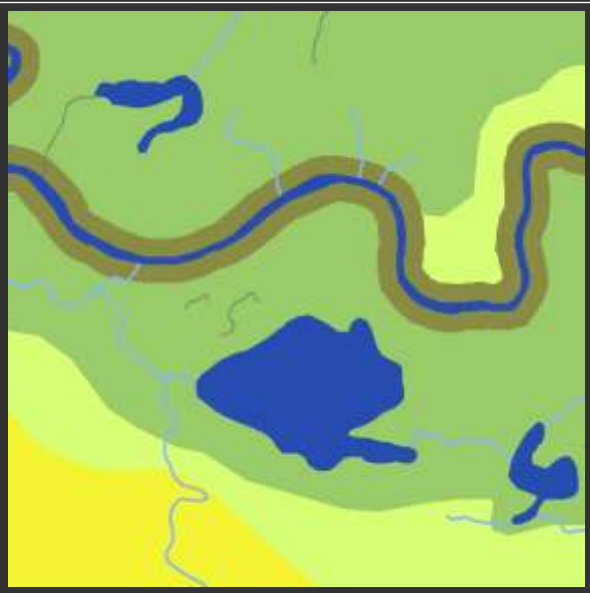


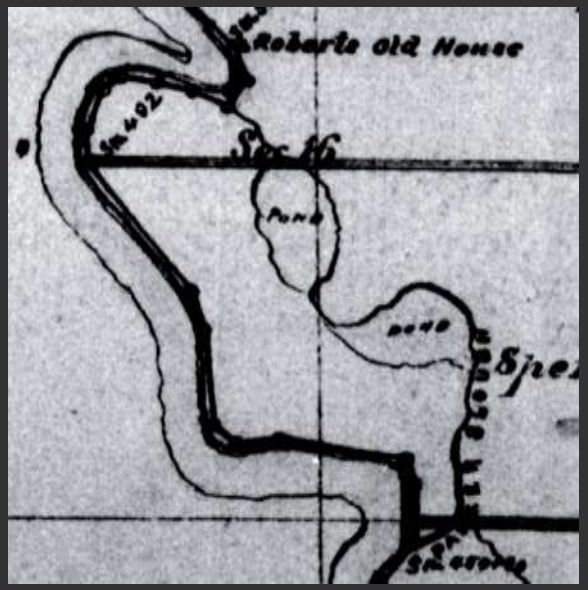
South Delta: where floodplains meet tides

- Lakes and ponds connected to rivers

*"Along the edge of the lowland…a **string of lakes connected by sloughs** extend throughout the greater part of the area."*

- Sweet et al. 1908





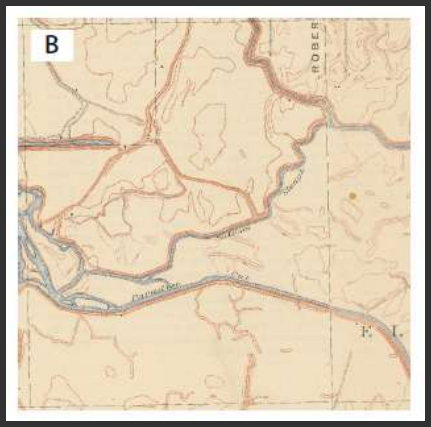
South Delta: where floodplains meet tides

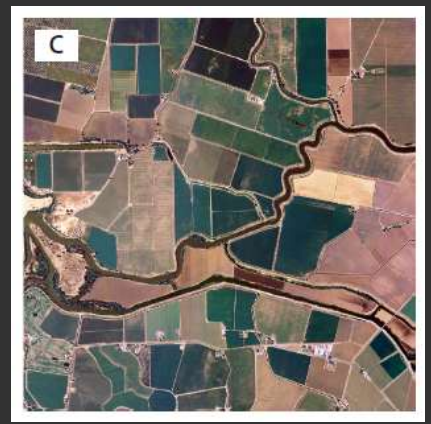
- Channel complexity

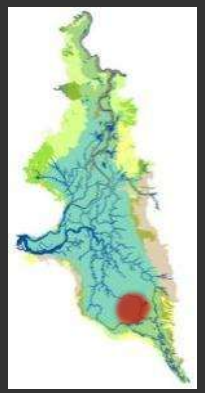
Salmon Slough: “The stream bed is **full of logs** and the boats grounded two or three times.” (Abella 1811)

“I came to a **raft of large timber**, and after some hard work in cutting and sawing logs, we succeeded in dragging our boat through.” (Gibbes 1850)

“…great many **old logs and an immense amount of driftwood** and rubbish in Old River” (Tucker Field Notes 1879)





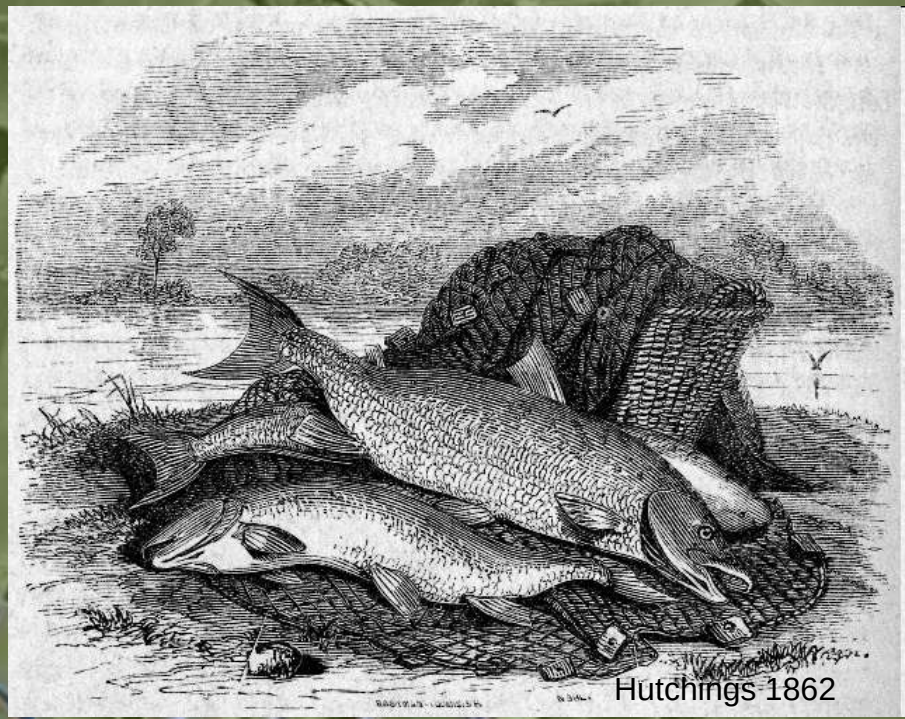


South Delta: where floodplains meet tides

"Río del Pescadero [Old River]…**fishing is done in it for salmon**."
(Cook 1960, "Report of Hermenegildo Sal," January 31, 1796)

"…it was **salmon, tenderer, fatter, and more savory**…for perhaps because there is so much fresh water here it grows larger, fatter, and better flavored."
(Bolton [ed] 1927, "Anza's California Expeditions" 1776)

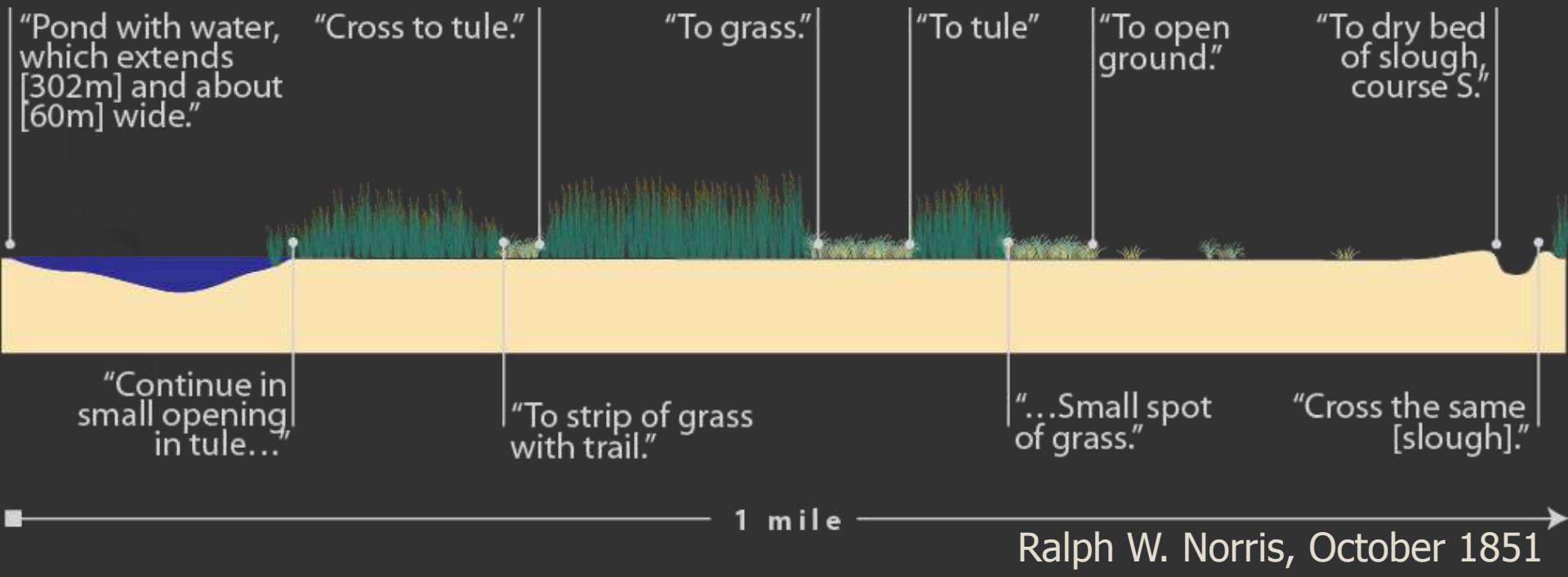
"…we rested here [El Pescadero] and passed the time well with **fresh salmon** and wild grapes" (Cook 1960, "Father Vaider's Second Trip," October 29, 1810)



Hutchings 1862

South Delta: where floodplains meet tides

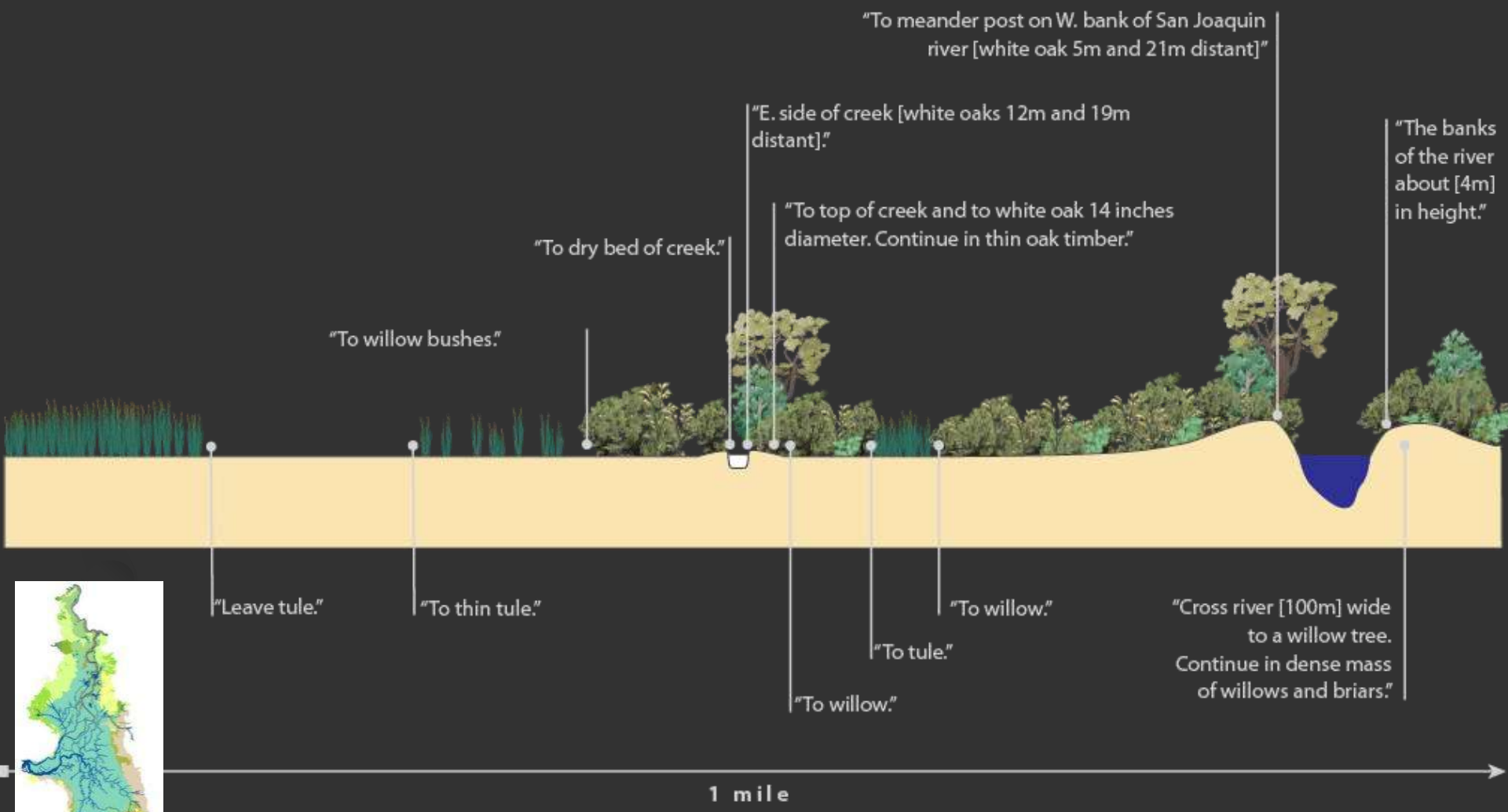
- Diverse suite of habitat types at local-scale



Ralph W. Norris, October 1851

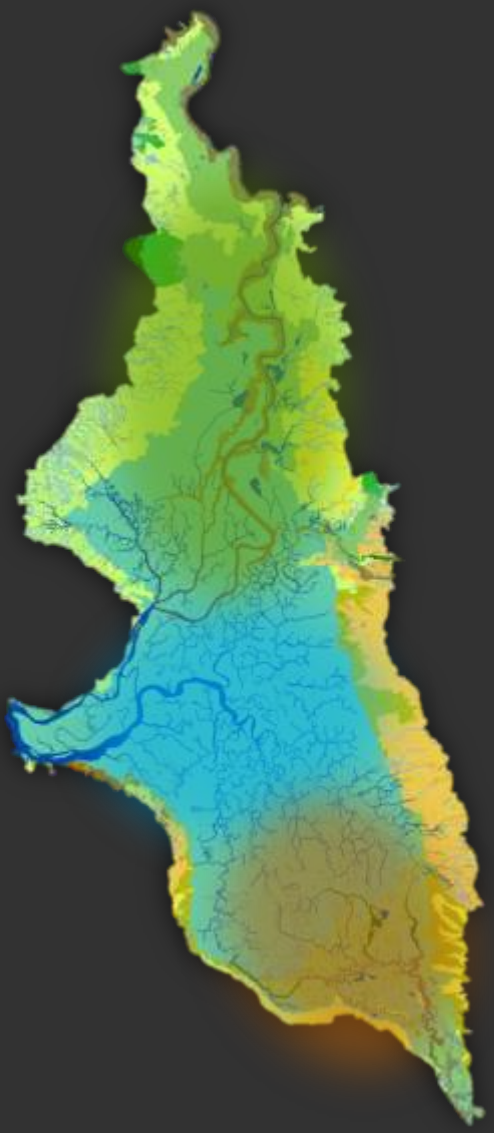
South Delta: where floodplains meet tides

- Diverse suite of habitat types at local-scale



Ralph W. Norris, October 1851

Landscapes summary



- Floods wetted and connected landscape
- Channels to lakes along gradient
- Riparian forest bordering tule basins

- High degree of tidal influence
- Networks of branching channels
- Tidal wetland of tule and willow-fern swamp

- Floods within a complex landscape meet the tides
- Side-channels connected to rivers
- Habitat type diversity at local scale

Implications

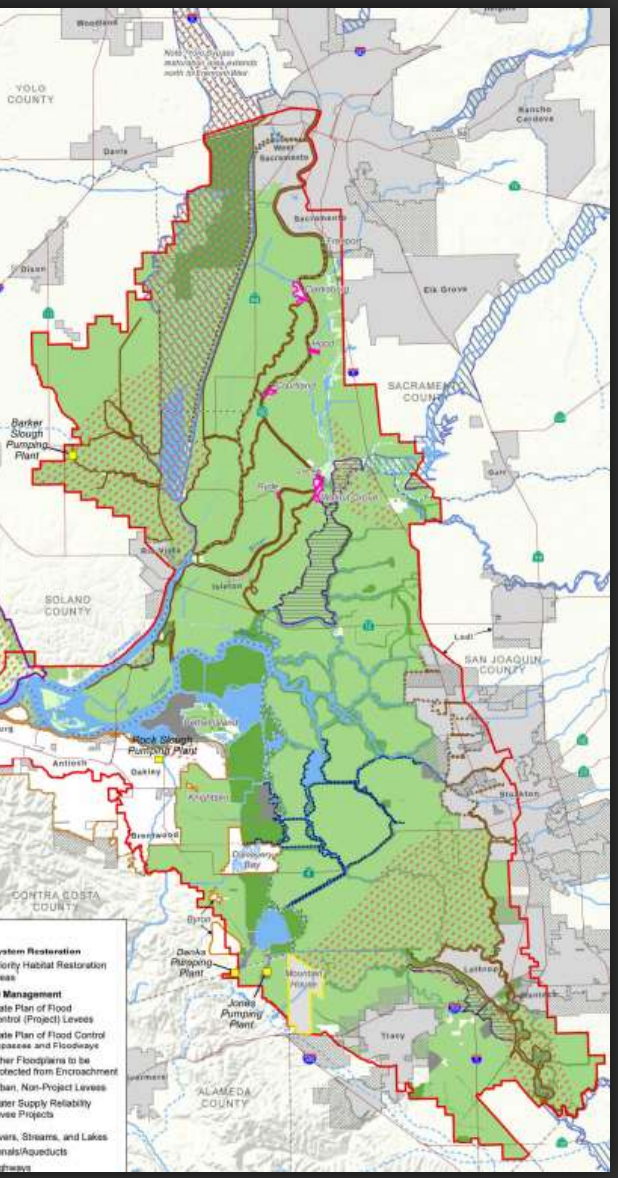


Figure 1-3, The Delta Plan

- Floodplain inundation
- Downstream connectivity through perennial wetland
- Adjacent riparian forest

- Appropriate elevation
- Tidal energy
- Scale of channel networks

- Floodplain inundation
- Dynamic river processes
- Topographic complexity

Talk outline

- What is historical ecology and why is it useful?
- How do we do historical ecology?
- Findings of the *Delta Historical Ecology Investigation*
- How is this information being used?

What is a realistic but positive vision for the future Delta?

- Importance of a positive message, something worth getting excited about
- Not just for healthy, resilient native fish and wildlife but healthy resilient human communities
- Importance of a narrative – a compelling, well-documented story of what we had, how we got here, and what could be done in the future

→ *Visualizations of what this landscape could look like in the future*

The Delta Landscapes Project

Management Tools for Landscape-Scale Restoration

Funded by the Ecosystem Restoration Program

ECOSYSTEM RESTORATION PROGRAM
California Department of Fish & Game
National Oceanic & Atmospheric Administration
US Fish & Wildlife Service

SFEI
AOSC

CALIFORNIA DEPARTMENT FISH & GAME

Project approach

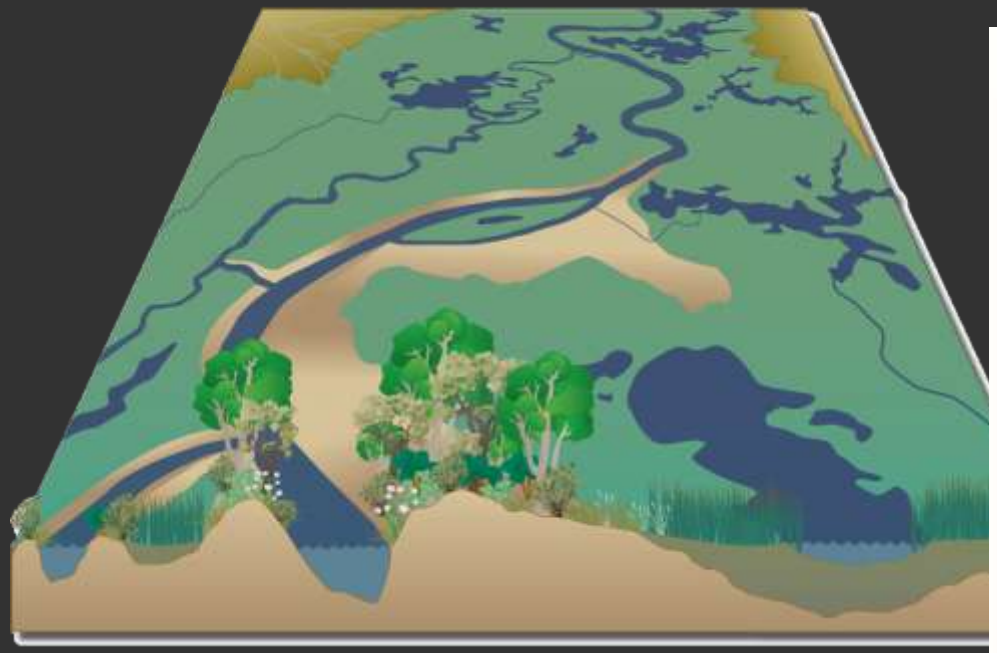
- How and where were desired ecological functions provided in a healthy Delta?
- How do we measure and quantify these functions?
- What constituted a functional landscape?
- Where could functional landscapes be supported today?
- What is a realistic vision for the future Delta?

Landscape Interpretation Team

Brian Atwater (USGS)
Stephanie Carlson (UC Berkeley)
Jim Cloern (USGS)
Brian Collins (University of Washington)
Chris Enright (Delta Science Program)
Joseph Fleskes (USGS)
Geoffrey Geupel (PRBO Conservation Science)
Todd Keeler-Wolf (CDFG)
William Lidicker (UC Berkeley)
Steve Lindley (NMFS)
Jay Lund (UC Davis)
Jeff Mount (UC Davis)
Peter Moyle (UC Davis)
Anke Mueller-Solger (IEP and Delta Science Program)
Eric Sanderson (Wildlife Conservation Society)
John Wiens (PRBO Conservation Science)
Dave Zezulak (CDFG)

What constituted a functional landscape?

ecological functions + **physical drivers** = **operational landscape unit**



Example landscape unit attributes

to be determined through landscape metrics analysis

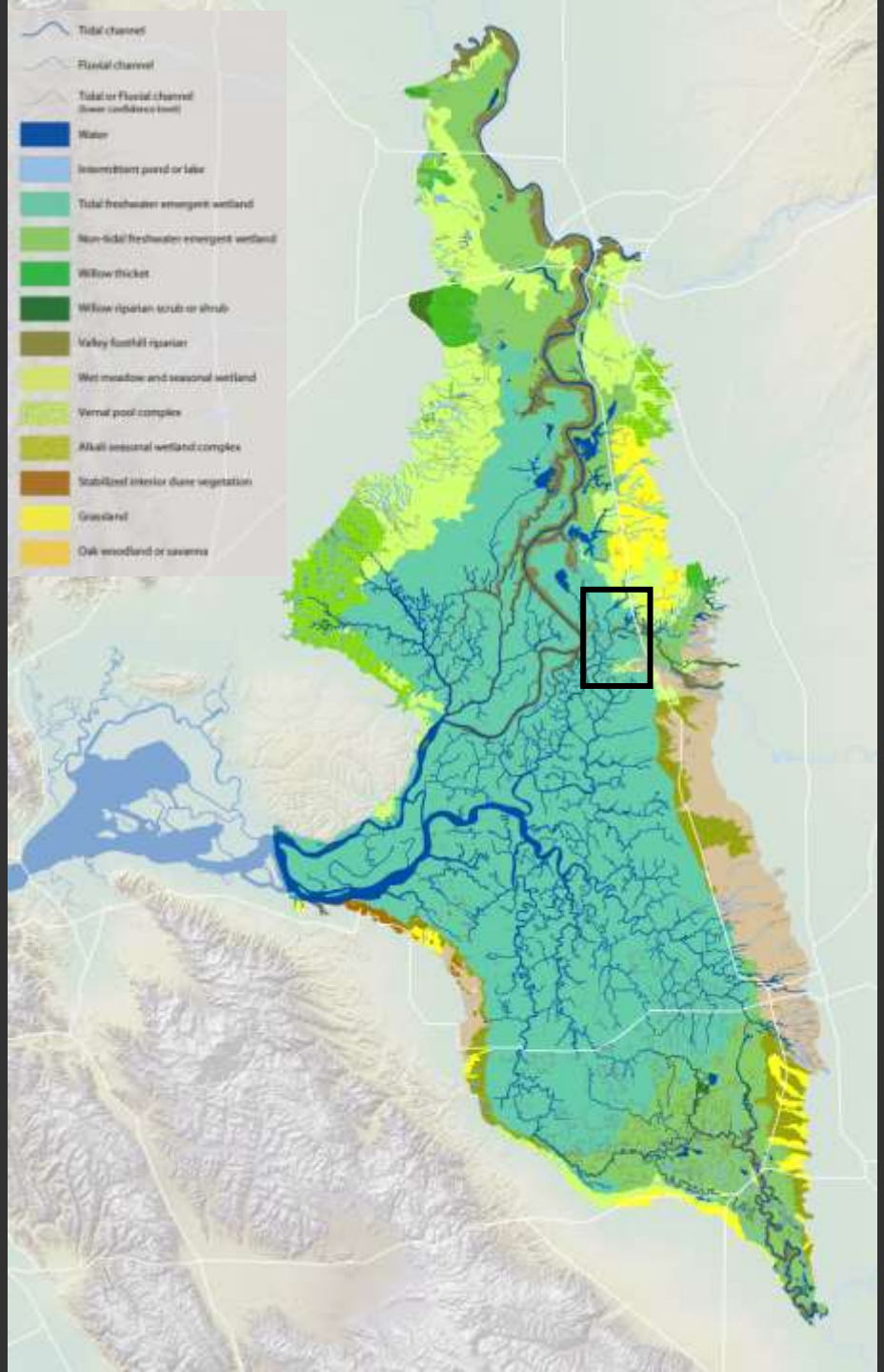
- {*XX frequency*} tidal inundation
- {*XX frequency*} fluvial inundation
- {*XX ha*} ponds and lakes adjacent to channels
- Broad natural levees {*XX m*} high
- Riparian forest {*XX m*} wide
- {*XX m/m²*} tidal channels
- ...

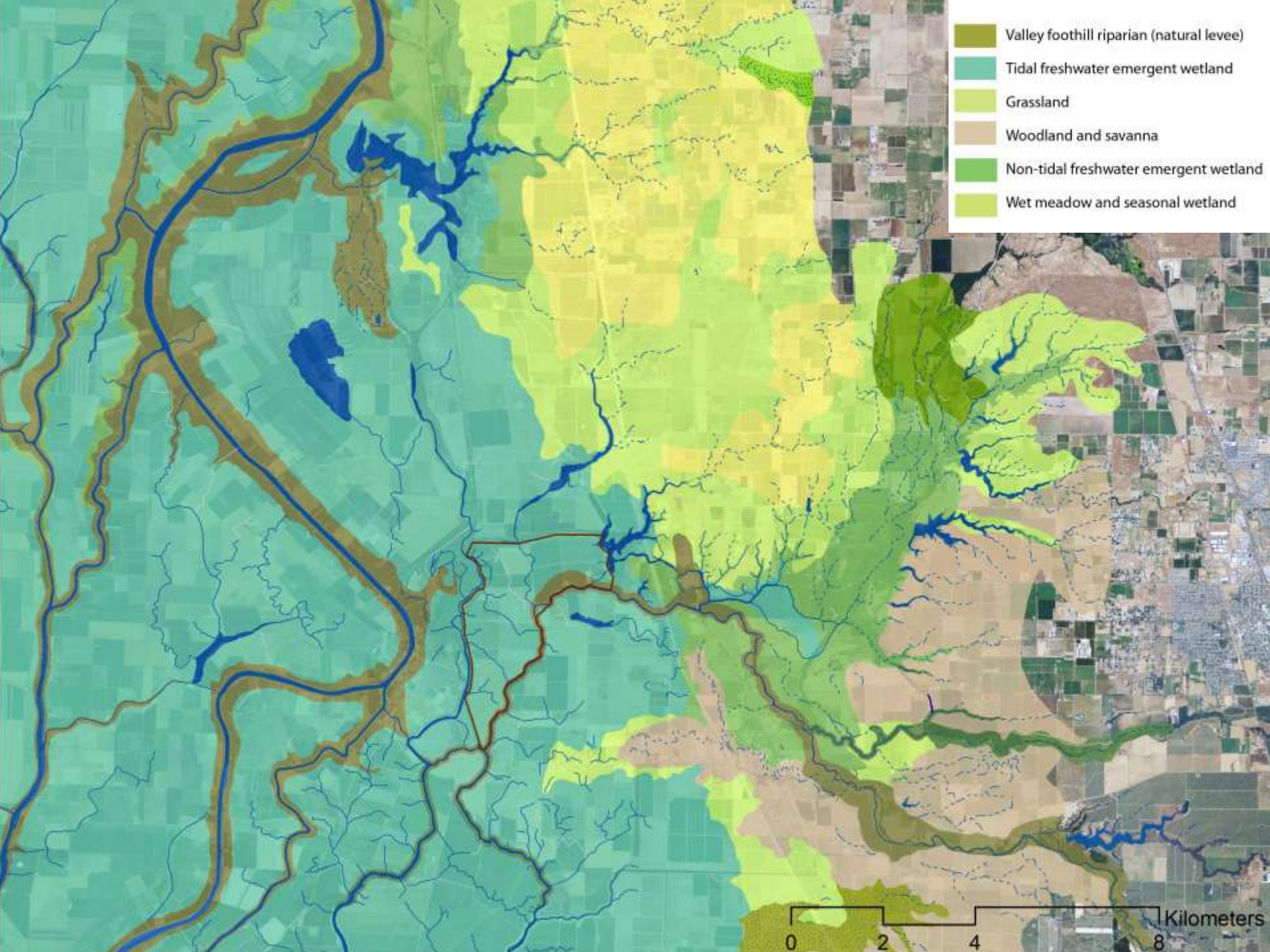
Where could functional landscapes be today?

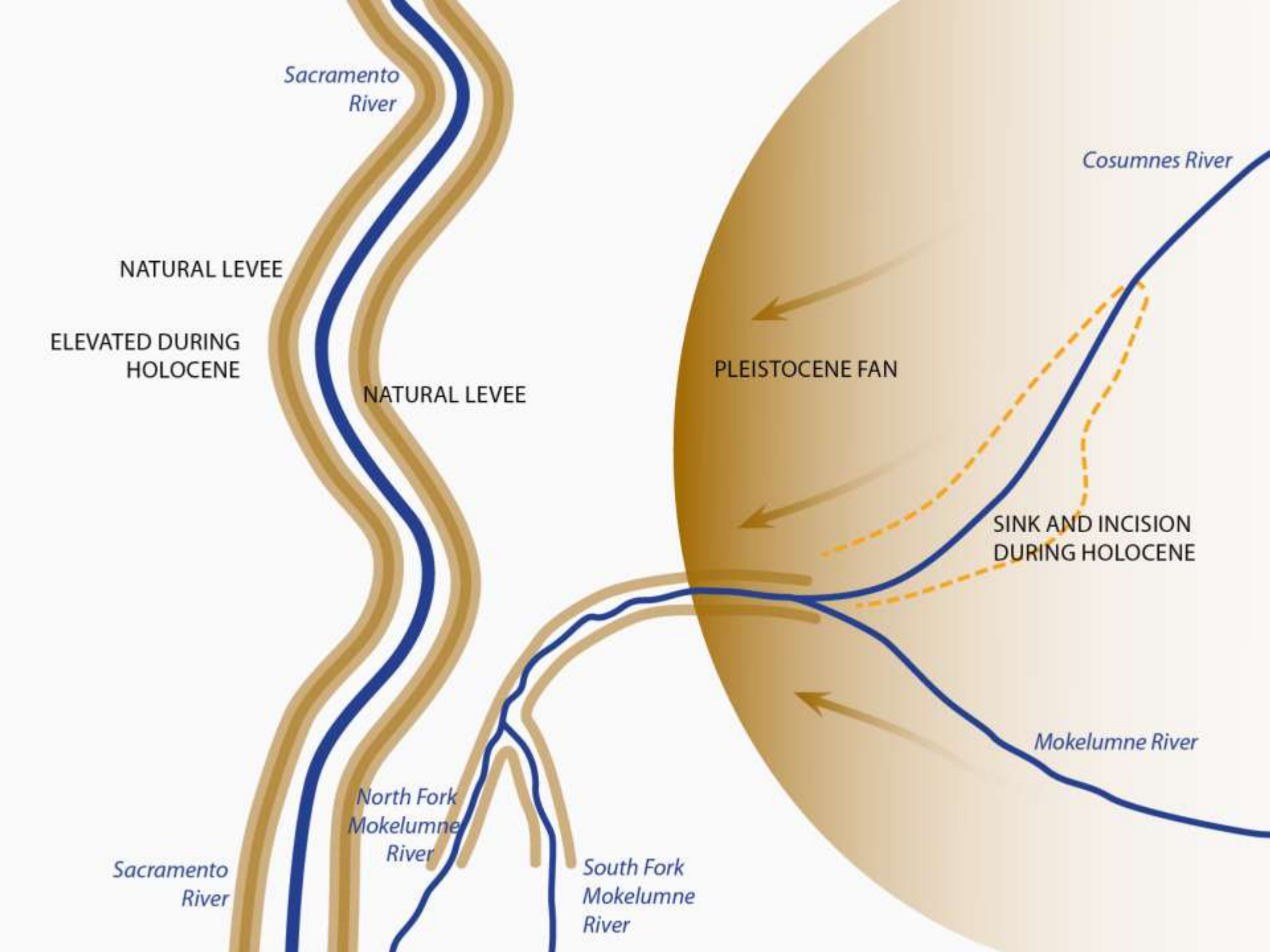
Case study: McCormack-Williamson Tract

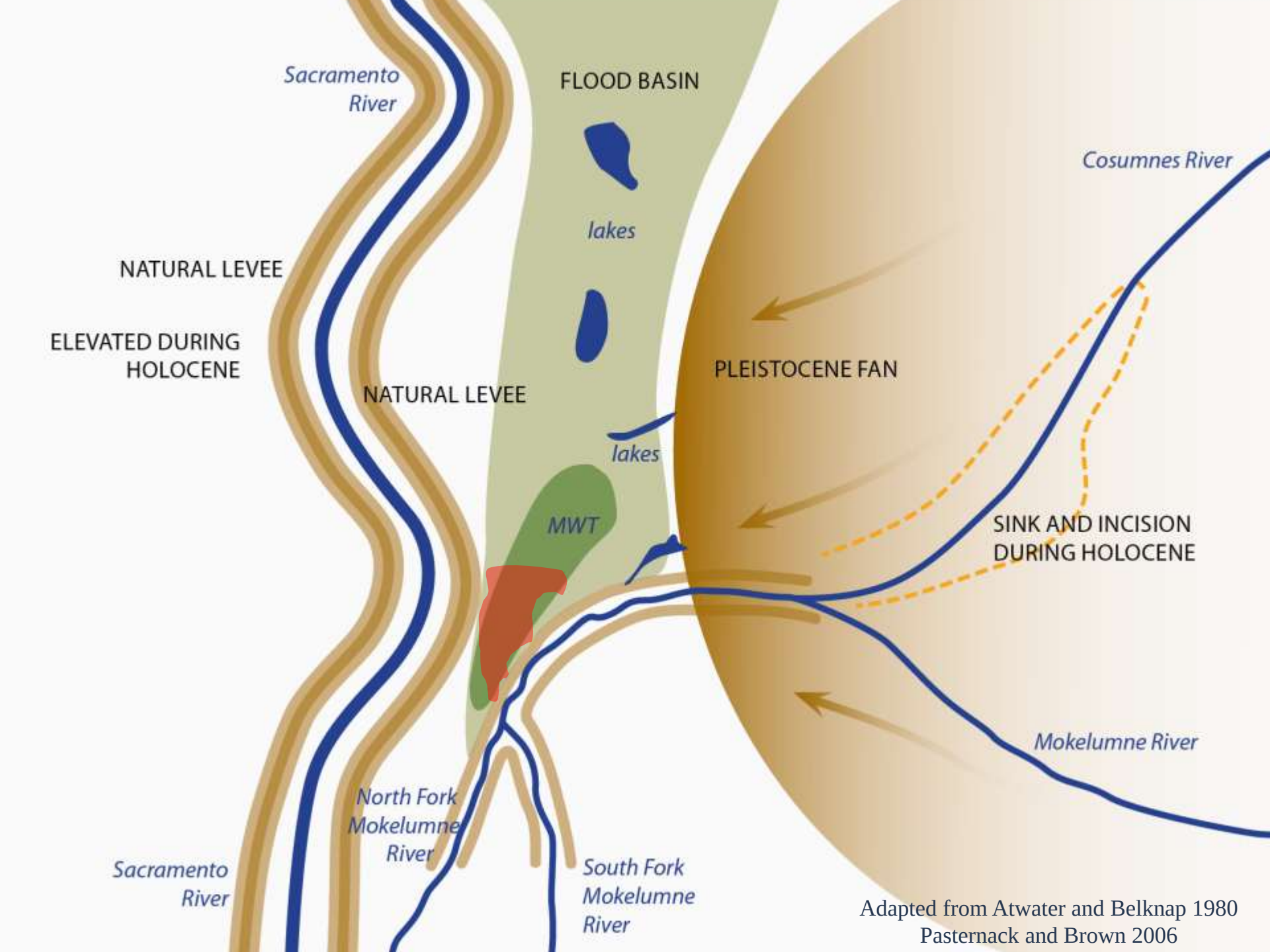
Opportunities

- Large restoration opportunity
- Variable topography
- Connection to uplands and tides
- Remnant historical features

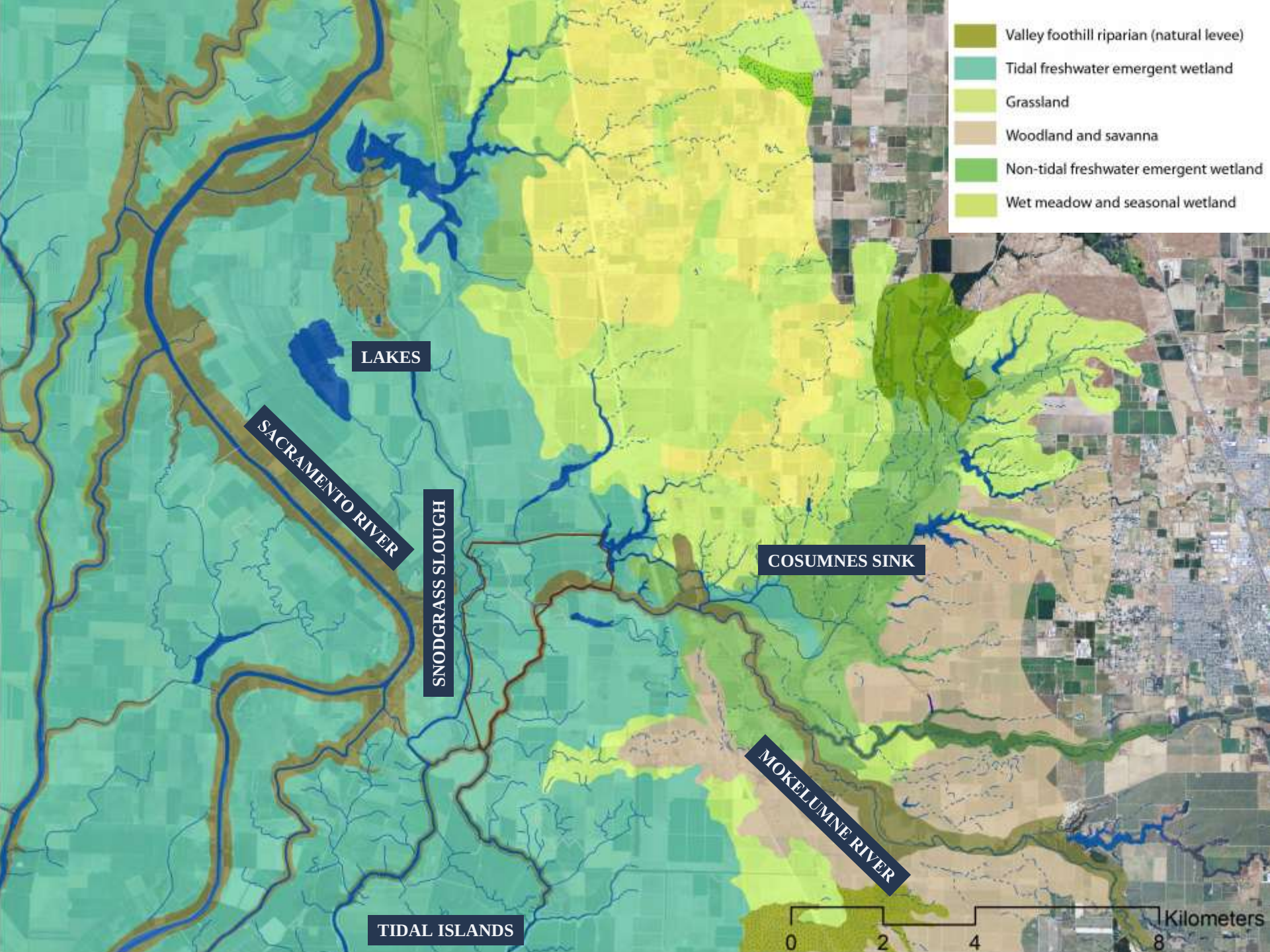

Tidal channel
Fluvial channel
Tidal or Fluvial channel
(lower confidence limit)
Water
Intermittent pond or lake
Tidal freshwater emergent wetland
Non-tidal freshwater emergent wetland
Willow thicket
Willow riparian scrub or shrub
Valley foothill riparian
Wet meadow and seasonal wetland
Vernal pool complex
Alkali seasonal wetland complex
Stabilized interior dune vegetation
Grassland
Oak woodland or savanna


Valley foothill riparian (natural levee)
Tidal freshwater emergent wetland
Grassland
Woodland and savanna
Non-tidal freshwater emergent wetland
Wet meadow and seasonal wetland
0
2
4
8
Kilometers

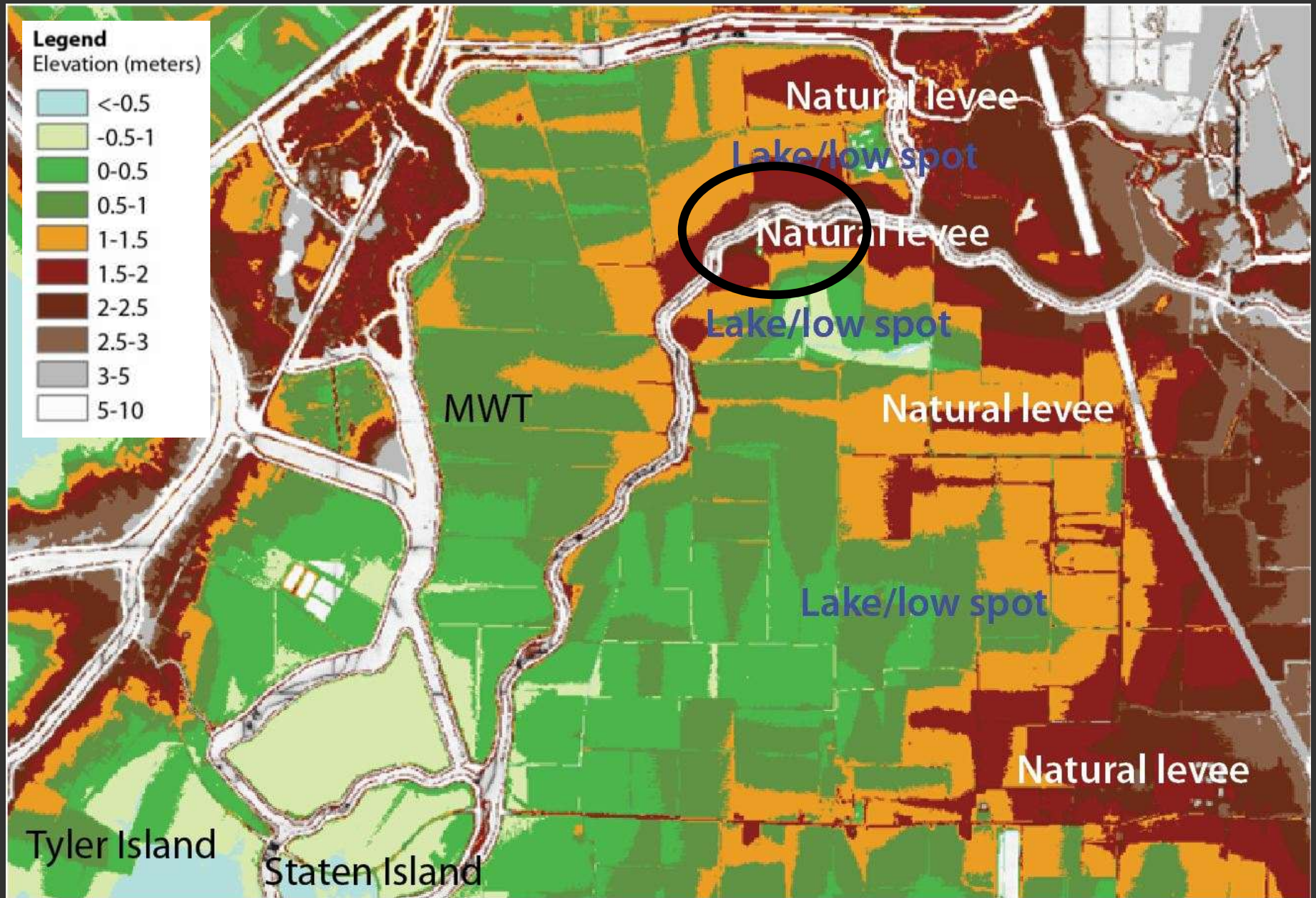

Sacramento River
NATURAL LEVEE
ELEVATED DURING HOLOCENE
NATURAL LEVEE
Cosumnes River
PLEISTOCENE FAN
SINK AND INCISION DURING HOLOCENE
Mokelumne River
North Fork Mokelumne River
South Fork Mokelumne River
Sacramento River

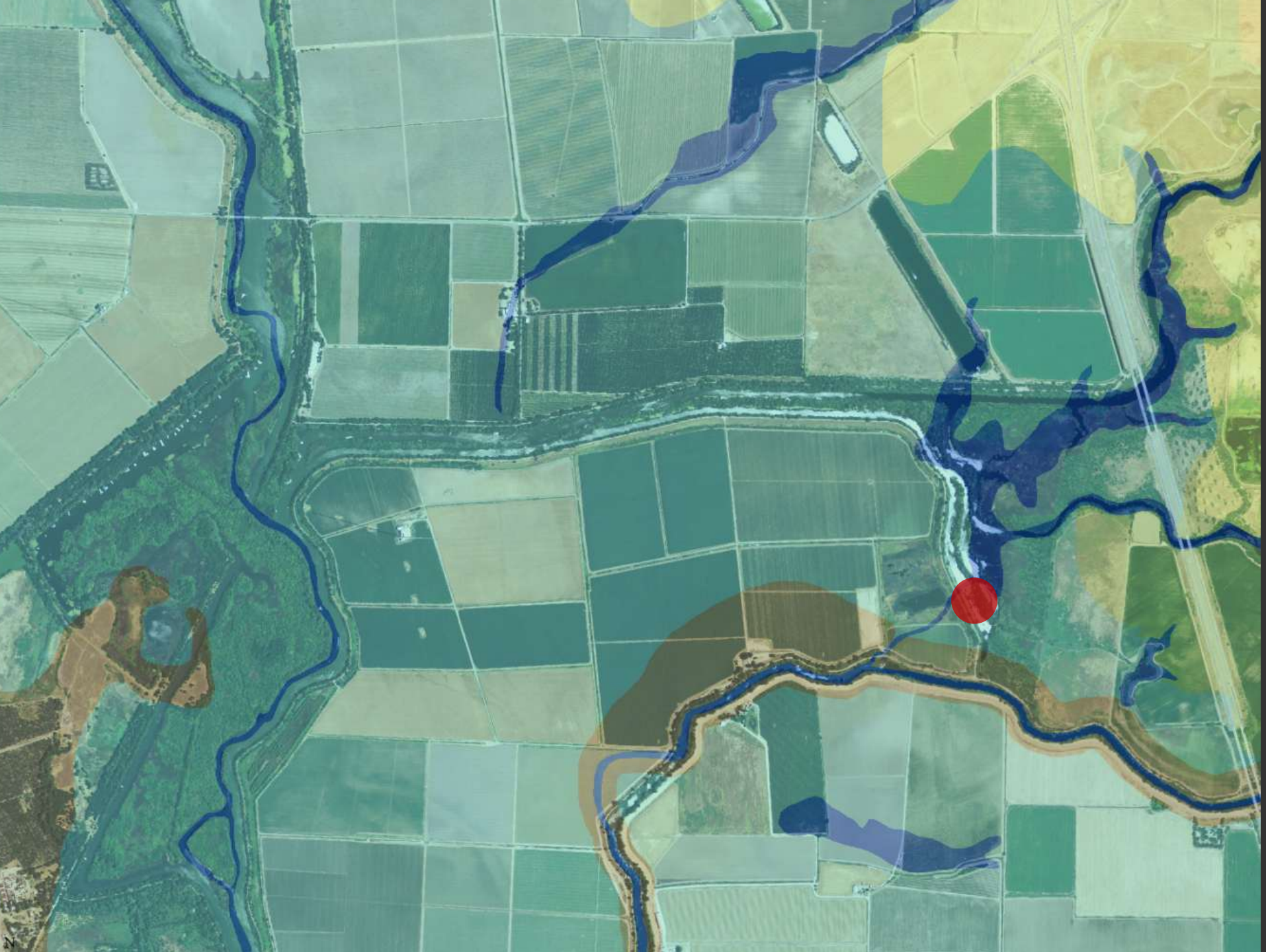


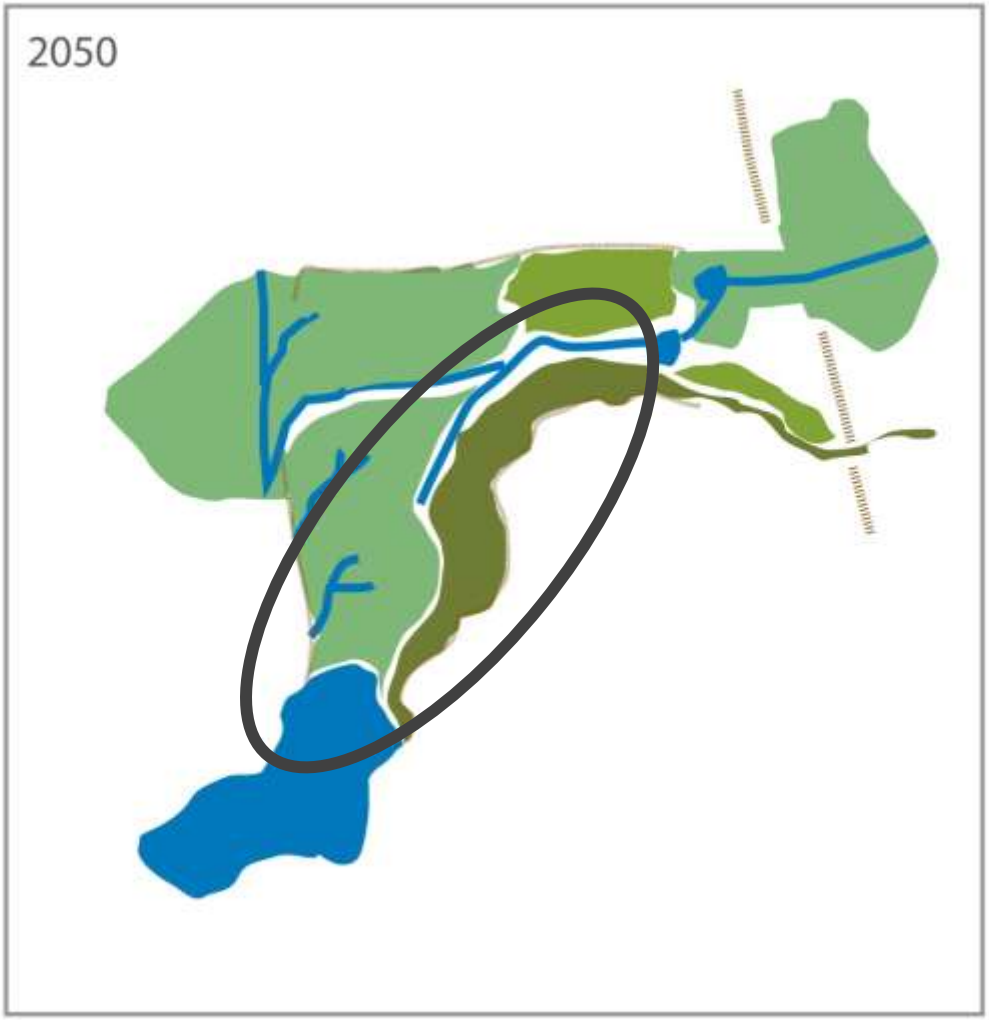
Adapted from Atwater and Belknap 1980
Pasternack and Brown 2006

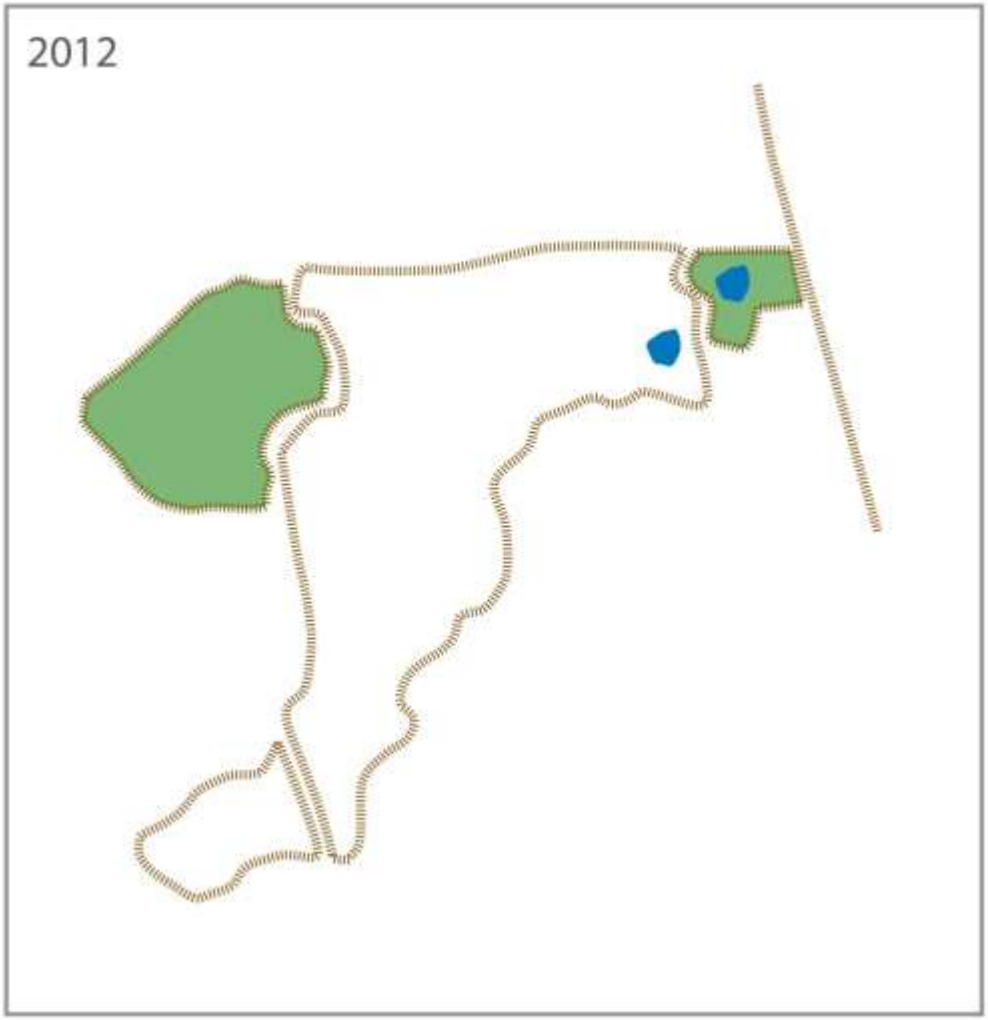

Valley foothill riparian (natural levee)
Tidal freshwater emergent wetland
Grassland
Woodland and savanna
Non-tidal freshwater emergent wetland
Wet meadow and seasonal wetland
LAKES
SACRAMENTO RIVER
SNODGRASS SLOUGH
COSUMNES SINK
MOKELUMNE RIVER
TIDAL ISLANDS
0
2
4
8
Kilometers

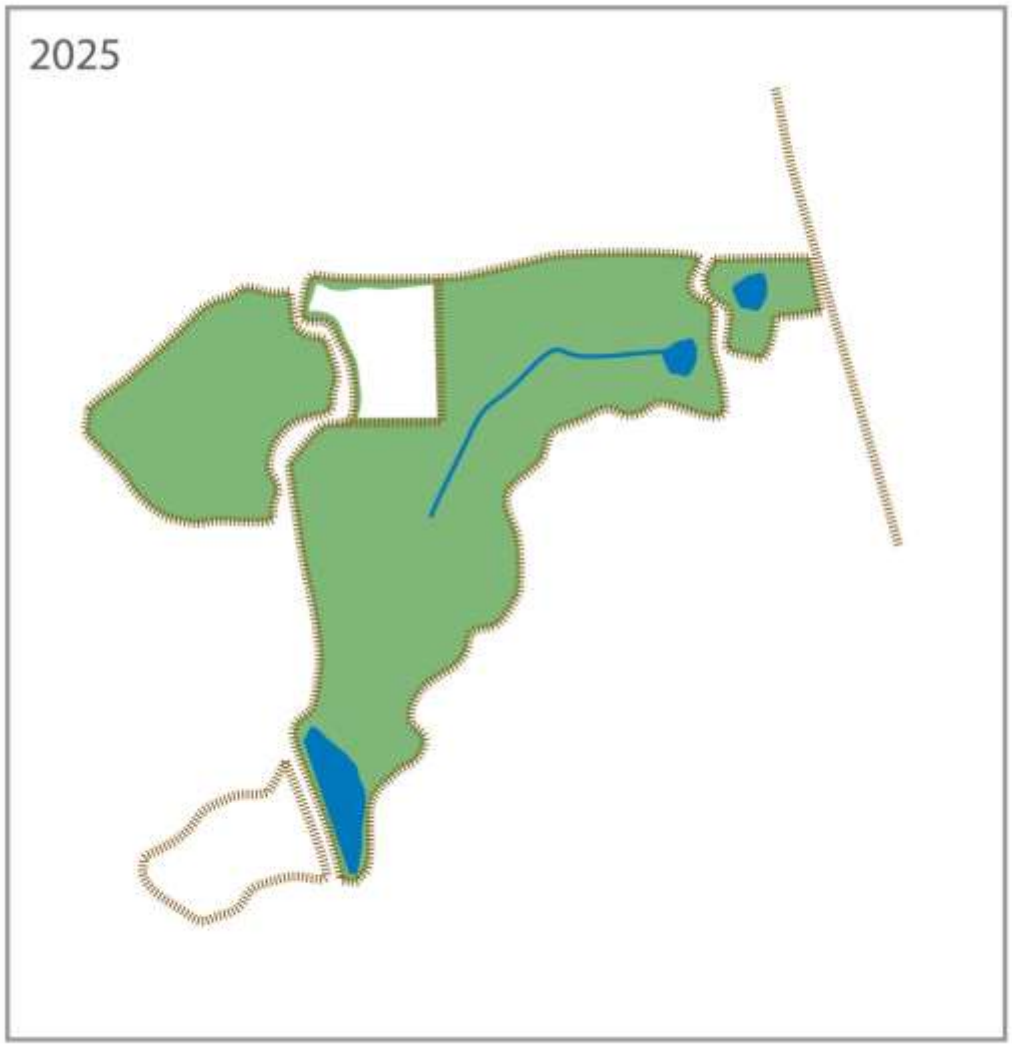
Topographic Variability

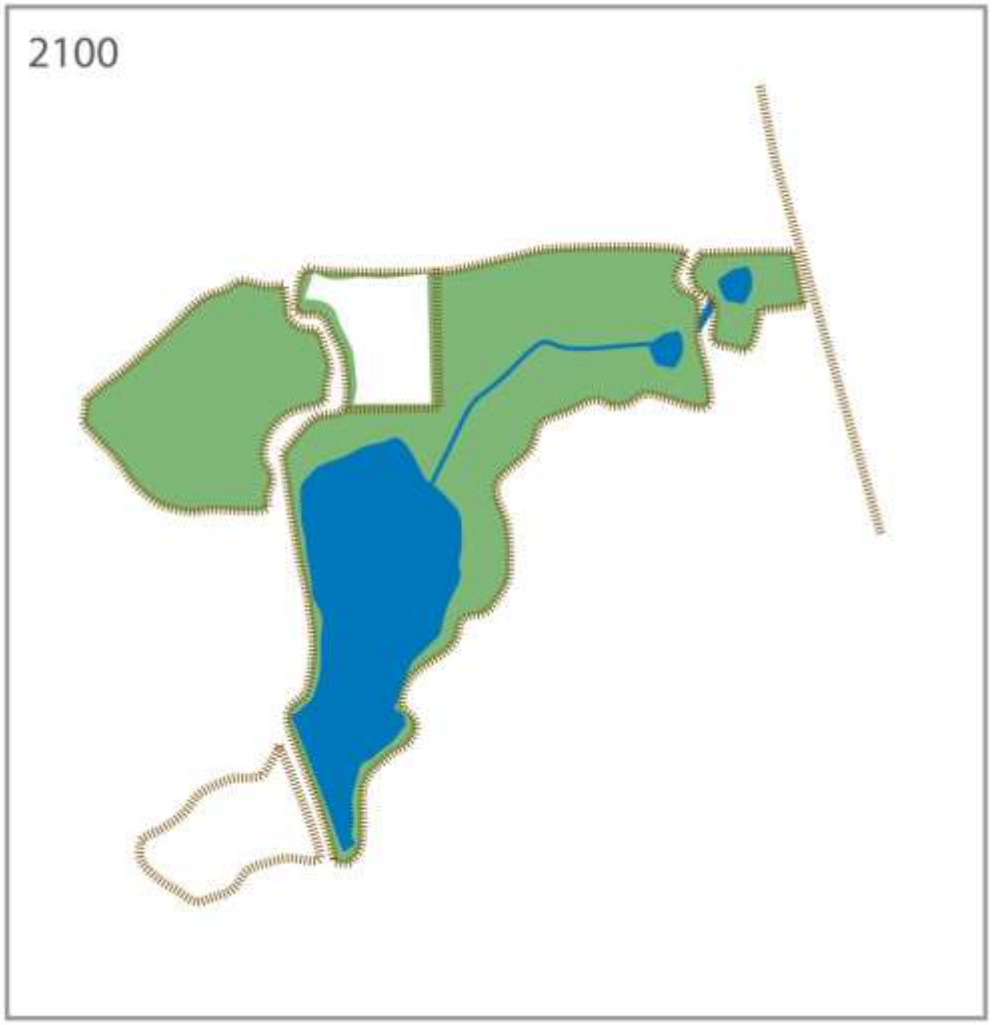


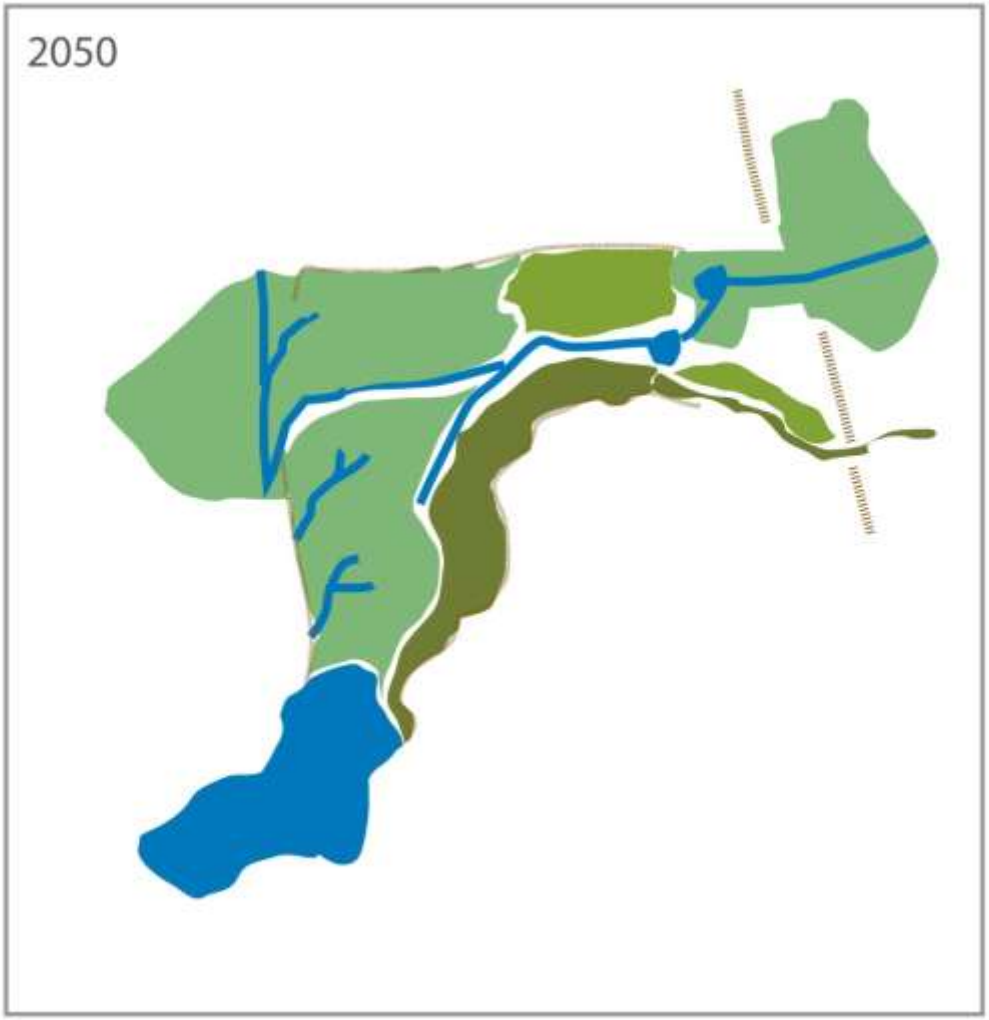


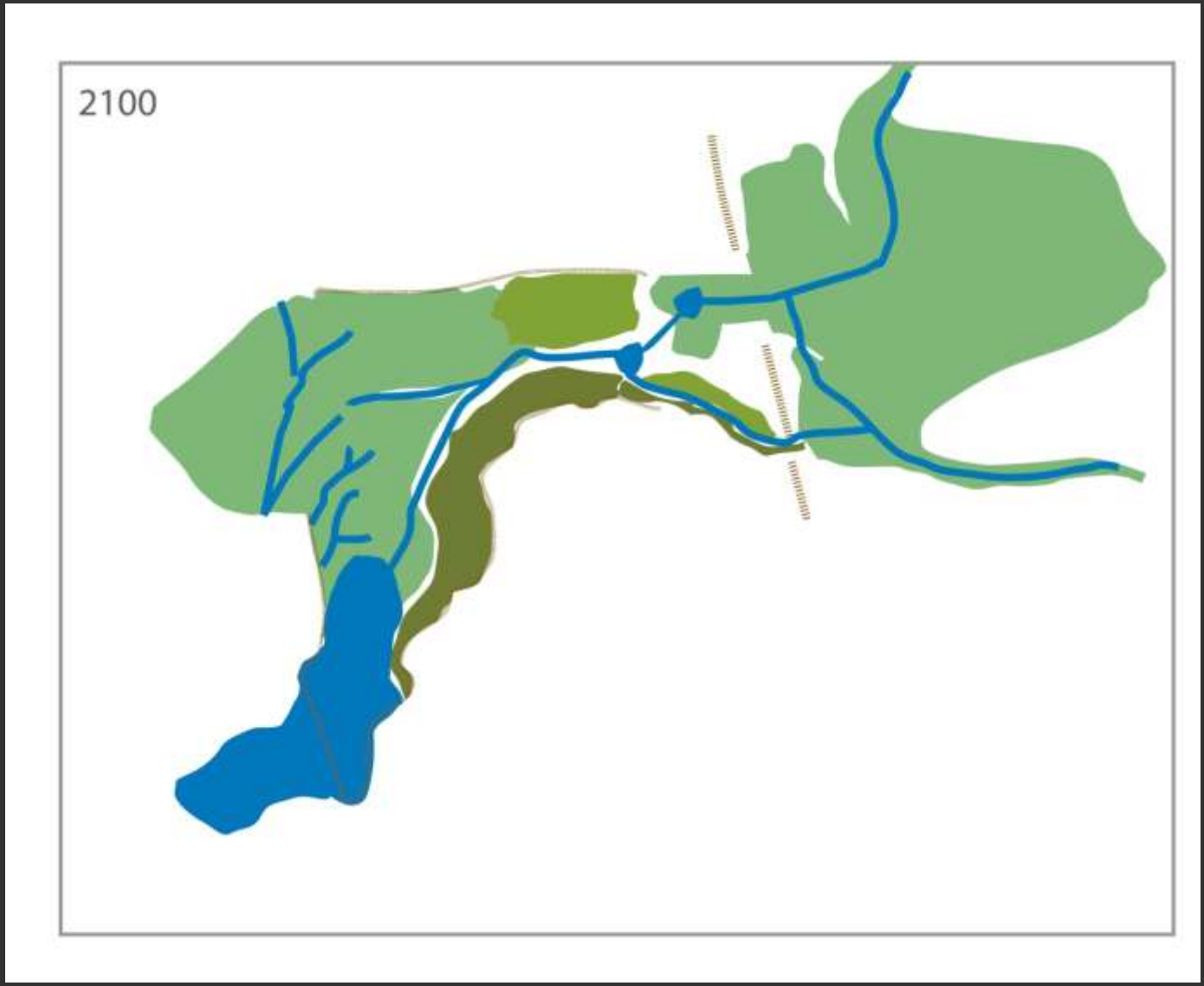

2050


2012


2025


2100


2050



is not what the landscape looked like in 1850.

Functional, resilient Delta landscapes could be re-established to support native species

- Can achieve higher function without restoring the past
- Physical gradients still remain: manage and plan with current and future expected physical gradients in mind
- Large and interconnected habitats may mean different things for different places (*functional landscape units*)
- Think at the large scale and in the long term
- The future will be different from both the present and the past, but emphasizing certain patterns and processes over others may yield a healthier ecosystem
- Restoration of individual parcels needs to add up to landscapes that fit into a vision for the whole Delta

THANKS

SFEI

Ruth Askevold
Julie Beagle
Erin Beller
Josh Collins
Jamie Kass
Maika Nicholson
April Robinson
Melissa Runsten
Sam Safran
Micha Salomon
Bronwen Stanford
Chuck Striplen

CDFG

Carie Battistone
Daniel Burmester
Bronwyn Hogan
Gena Lasko
Amy Lyons
Daniel Rankin
Ciprian Simon
Carl Wilcox
Dave Zezulak

Cliff Dahm, Anke Mueller-Solger, Chris Enright
Leo Winternitz
The LIT

CDFG, ERP, and TNC for funding

ECOSYSTEM RESTORATION PROGRAM
California Department of Fish & Game
National Oceanic & Atmospheric Administration
US Fish & Wildlife Service

The Nature Conservancy

THANK YOU

robin@sfei.org

alison@sfei.org

www.sfei.org